

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.



NOV 7 1968

PROGRESS REPORT

of the

CURRENT SERIAL RECORDS

TRANSPORTATION AND FACILITIES RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

This progress report includes a summary of the current research of the Division and a preliminary report of progress made during the preceding year. It is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1967, and June 30, 1968. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Transportation and Facilities Research Division, Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

July 1, 1968

TABLE OF CONTENTS

Introduction.....	iii
Area No. 1: Planning Marketing Facilities.....	1
Area No. 2: Dairy Products - Marketing Facilities, Equipment and Methods.....	8
Area No. 3: Field Crops - Marketing Facilities, Equipment and Methods.....	11
Area No. 4: Horticultural Crops - Marketing Facilities, Equipment and Methods.....	21
Area No. 5: Livestock, Meat, and Wool - Marketing Facilities, Equipment and Methods.....	34
Area No. 6: Poultry and Eggs - Marketing Facilities, Equipment and Methods.....	40
Area No. 7: Consumer Packages and Shipping Containers.....	47
Area No. 8: Transport Equipment and Techniques.....	54
Area No. 9: Wholesaling, Retailing and Institutional Food Service.....	66
Miscellaneous.....	75

INTRODUCTION

Transportation and marketing facilities research of ARS as used in this report is concerned with the structures, equipment, containers, devices, work methods, and operating methods used in marketing and transporting farm and food products from the farms to consumers. It seeks to find ways to improve these physical elements and handling methods in order to increase their efficiency and effectiveness in performing the numerous operations involved, increase labor productivity, and help hold down marketing costs. The research deals largely with the application of engineering--economic and marketing principles. The functions to which these physical elements, handling methods, and labor relate include essentially all marketing operations, especially those directly applicable to the commodities in the physical sense, such as assembling, preparing for market, processing, packaging, precooling, loading, transporting, unloading, storing, warehousing, and wholesale and retail distribution.

Our system of producing and distributing food is supplying consumers \$86 billion worth of food annually. In 1967, it cost \$28 billion for growing the food and \$58 billion for marketing it. There is considerable evidence that the research done during the past 20 years to make marketing more efficient is paying off. Labor cost per unit marketed has gone up only about one-third as much as wage rates of labor engaged in these activities (during the past 20 years, labor costs per hour went up about 120%, but due to the increased efficiency the labor cost per unit marketed increased only 40%). If the full increase in the cost of labor during the past 20 years had been reflected in higher marketing costs, the total annual food marketing bill now would be about \$10 billion greater than it is. Seventy-five percent of the total food marketing bill is directly affected by research in the areas covered by this report.

Most of the research by industry differs substantially from that done by public agencies. It relates primarily to the development of products or services which the individual firms offer for sale and is profit oriented. Some of the research and developmental work of industry involves adaptation of research findings of public agencies. Most of the research findings are trade secrets and therefore not made public. Thus, research contributions to public knowledge in this field must come mainly from public-supported research. Such research has special significance to the small firms that cannot afford to do their own research.

Industry contributes to USDA research in numerous ways, particularly in permitting the free use of its facilities, equipment, materials, and supplies in numerous research experiments and tests. Also, in some cases, industry groups have made cash contributions to help finance USDA research in this field. Research by USDA frequently serves as a catalyst or stimulus to industry research. Indicative of the research results being obtained and the extent of their application by industry are the following examples:

Urban Food Distribution Facilities. The New England Produce Center in Boston began operations in February and facilities for meat and other products are under construction. The new facilities provide the Boston area with modern, efficient food distributing facilities replacing some that were over 200 years old. The new Regional Food Market in Springfield, Massachusetts, which opened this year is already being expanded. Sites for the new facilities for Baltimore and Milwaukee have been selected and final plans for building them are being made. Plans to expand New York City's new Hunts Point market from the initial 126-acre fruit and vegetable facility to a 350-acre food distribution center have been developed. Studies to improve the distribution of food in Cincinnati, Oakland, Honolulu, Salt Lake City, and Minneapolis were completed during the year. These studies call for building over \$35 million worth of new facilities in these cities. The largest single study ever undertaken by ARS to improve urban food distribution was begun in Los Angeles. More than 1,200 food distributors, both large and small, are involved in this study. Plans to expand facilities previously built in Greenville, and Columbia, South Carolina, and Raleigh, North Carolina, were developed this year. To develop improved technology for planning urban food distribution facilities an evaluation was made of alternate methods of supplying refrigeration. It was found that a centralized system to supply refrigeration to all distributors in a market is more economical to build and operate than for each firm to install its own refrigeration.

Marketing Facilities in Producing Areas. Construction is expected to begin soon in Kennett, Missouri, on the largest goose processing plant in the country. In Waco, Texas, one of the first hot cut-up lines for turkeys in the country is now operating on an experimental basis. This experimental operation was reported to have more than doubled the production output of the old, conventional cut-up operation. A study to improve apple-packing facilities in the Shenandoah Valley of Virginia will provide demonstration facilities that should prove beneficial to the entire Appalachian apple industry. These are examples of the kinds of plans which were developed during fiscal year 1968 for 21 marketing facilities of various types in producing areas of 14 states.

Cut-up Machine for Broilers Reduces Processing Cost. A broiler cut-up machine developed by Division engineers is now undergoing tests in a commercial broiler processing plant; confirming the inventors' predictions that it would reduce processing costs materially while minimizing hazards to product wholesomeness. In operation, the eviscerated carcass is threaded onto a triangular bar and held in position mechanically while being moved past three rotary knives by a power-driven chain. The chicken is split and the vertebra removed simultaneously. Various chicken parts can be obtained as desired. If drumsticks and wings are removed before the carcass is fed into the machine, and the flank skin cut, the back, thighs and breast halves fall away from the cutting assembly, ready to pack. If whole breasts are desired, the knife that splits the breast can be quickly removed. Then, instead of removing the vertebral column the whole chicken can be split in half. Other cuts can be made with simple adjustments. The cut-up machine replaces from

two to four workers in manual operations and will cost about one-half the annual wages of one worker. A commercial plant with an average size cut-up operation should save up to \$20,000 annually using the new equipment. A public patent application has been prepared and filed.

Machine to Separate Splits From Whole Peanut Kernels. Peanut shelling tests have pointed up the difficulty in separating splits from whole kernels, especially when both are about the same size. Current methods require a substantial amount of hand-picking and extra equipment to make this separation. Industry reports substantiate this finding and describe it as difficult in "making" U. S. Grades on No. 1 and Splits for Virginia-type peanuts and on No. 2, Small Rounds, and Splits for Runner-type. Current industry practice also reduces the market value of the mid-grade peanuts, and often produces "dirty" splits of minimum value.

A new principle of separation, based on the difference in the configuration between a whole and split kernel, has been tested with a laboratory model of a separator which consists of a feeding device, kernel orienting mechanism and adjustable inclined belt conveyor. In operation, split kernels are fed to the belt flat side down. Whole kernels then roll to the bottom of the conveyor and are collected, while split kernels are carried to the top. Operation is continuous. Performance tests showed that all but 2 percent of the splits of Virginia-type peanuts (the most difficult to separate) were removed, thus meeting U. S. grades. Using the new separator an average peanut shelling plant receiving 1,000 tons of farmers stock peanuts annually can produce at least 50 tons of higher value shelled goods. Based on current prices, the value of the peanuts is increased by \$8,000. Reduced labor and equipment costs will save an additional \$6,000.

Design Criteria for Potato Storages. Shortages of labor for handling potatoes in old and antiquated facilities in potato storage areas are forcing the construction of modern facilities. Older storages in Maine, Idaho, Red River Valley, and elsewhere are now being replaced by new facilities at an increasing rate. To provide guidelines for this new construction, plans and specifications have been developed for four different types of potato storages for the fall-crop areas: (1) 60,000 cwt. door-per-bin, (2) 20,000 cwt. arched roof, (3) 60,000 cwt. cross alley and (4) 25,000 cwt. pallet box. These recently released plans provide the most up-to-date guidelines available to architects, contractors, producers, and storage operators for constructing modern potato storage facilities. It is estimated that the use of these storage plans can save builders a minimum of 5¢ per cwt. in construction costs. If the industry continues to replace old storages at the rate of 10 percent annually, the saving in construction costs would amount to \$1,000,000 per year. The newer facilities would permit the use of more efficient handling and packing methods, reduce bruising and other damage, maintain better quality, and reduce spoilage at a saving of at least 10¢ per cwt. per year. Over a 5-year period the saving to the potato industry should reach \$35,000,000 assuming the 10 percent rate of replacement. At the same time, the consumer would receive better quality potatoes and savings should be passed back to the producers.

Air Transport of Carnations in the Bud Stage. Most flowers, including carnations, are relatively light in weight and take up more space than most products, thereby resulting in a high cost per pound shipped. USDA researchers have found that carnations cut and shipped in the bud stage and allowed to open to full bloom after delivery to destination markets have about twice the density in shipment as flowers cut and shipped in full bloom. Air shipping tests and cost analysis show that the industry can save over \$1,000,000 a year on carnations transported by air out of California and Colorado.

Overseas Transport Research Increases U. S. Exports of Citrus Juices and Fresh Vegetables. Shipments of single-strength citrus juice and fresh vegetables from Florida to European markets have grown from almost nothing to more than \$3,000,000 in the past two shipping seasons. The increase followed shipping experiments in refrigerated container vans in cooperation with citrus processors, vegetable shippers and ocean carriers. Exports of orange juice have increased to 2,196,000 gallons and grapefruit juice to 772,000 gallons in the period from July 1, 1967 to March 1, 1968. One hundred and ninety-six van loads of fresh vegetables worth more than \$500,000 have been exported from Florida to Europe. Florida shippers expect the volume of shipments to double or triple during the next year if sufficient van containers are made available to them.

Containerization Reduces Costs of Shipping Frozen Poultry to Overseas Markets. Labor costs for loading poultry at the processing plants, moving it on and off ships and for unloading it at the European receivers' warehouses was only one-seventh as much for containerized shipments of poultry as for break-bulk shipments. Labor costs were 0.1 cent per pound for the movement in van containers and 0.7 cent per pound for movement in break-bulk shipments. Containerization also helps to reduce costs of packaging. Less costly 200-pound test fiberboard boxes performed as well as 275-pound test boxes. The new boxes cost 3.5 cents less than the commonly used 275-pound test boxes. Elimination of metal straps around each shipping container also saved 3.2 cents per box. General adoption of less costly packaging for frozen poultry shipments to Europe would permit savings of \$180,000 annually.

New Shipping Containers Reduce Costs of Marketing Fresh Apricots and Prunes. Less costly shipping containers--fiberboard boxes--have been developed to replace wood boxes and wood-veneer baskets for shipping fresh apricots and prunes. The apricots and prunes are jumble-packed in the fiberboard boxes. Costs of packing and transport are 1.5 cents less per pound for marketing apricots in jumble-packed fiberboard boxes than face-packing the fruit in wood boxes. Packing and transport costs are 1.8 cents less per pound for jumble-packing fresh prunes in fiberboard boxes than for ring-facing them in wood-veneer baskets. General adoption of these fiberboard boxes would result in annual savings of \$530,000 for apricots and \$953,000 for prunes. Marketing fresh apricots in the new fiberboard boxes did not significantly reduce bruising of the fruit in transit. Thirty-three percent of the apricots

were bruised when marketed in the new fiberboard boxes as compared with 36 percent in the wood boxes. Less prunes were bruised when they were marketed in the new boxes. Only 7 percent of them were bruised in the fiberboard boxes as compared with 21 percent when they were shipped in wood-veneer boxes.

Increased Labor Efficiency Offsets Increased Wages. Hourly labor costs for food wholesalers and retailers increased from an index of 107 in 1939 to 341 in 1954, approximately a threefold increase. During this same period, unit labor costs (the cost of handling a single unit at retail) increased from 80 to 174, approximately a twofold increase. The Department started its research to increase labor efficiency in food wholesaling and retailing in 1950. From 1954 to 1963, the index for hourly labor costs increased from 341 to 475, another increase of 135 points, while unit labor costs decreased from 174 to 170. Thus, during the time the research program has been effective, increased hourly rates have been more than offset by increased labor efficiency and thereby saved the consumer billions of dollars. Industry spokesmen give the Department's research program on wholesaling and retailing the major share of credit for furnishing the technical information and leadership in making their performance possible.

AREA 1

PLANNING MARKETING FACILITIES

(RPA 509 - MARKETING FIRM AND SYSTEM EFFICIENCY)

USDA and Cooperative Program

<u>Location of Intramural Work</u>	<u>Scientist Man-years FY 1968</u>
<u>Urban Area Facilities</u>	
Maryland (Hyattsville)	11.1
<u>Producing Area Facilities</u>	
Maryland (Hyattsville)	
Poultry and Eggs	2.6
Fruits and Vegetables	1.4
Food Warehousing	.9
Dairy Products	.8
Livestock and Meat	.7
<u>Total</u>	<u>17.5</u>

Intramural program is supplemented by extramural support representing 1.6 SMY's at other U.S. institutions.

Problems and Objectives

Various kinds of marketing facilities are used in distributing food. They are used near farms to assemble food and condition it for movement to urban areas. In urban areas, others receive this food, break it down into smaller quantities, and with or without further processing move it on to retail outlets and consumers. Many of the facilities throughout the system are outdated and inadequate. They cause handling methods that are inefficient and costly. Improving these facilities so they meet the needs of a modern, efficient, food distribution system could reduce the cost of moving food through them by an average of 25 percent.

Major objectives of the research are to reduce the costs of food marketing and to provide an orderly, efficient, food distribution system by:

1. Developing criteria and technology for planning improved facilities.
2. Providing technical assistance in planning improved facilities.
3. Promoting the development of improved facilities.

Progress - USDA and Cooperative Programs

A. Urban Area Facilities

1. Cincinnati, Ohio. The determination of the need for improved food distribution facilities for Cincinnati has been completed. New facilities having over 860,000 square feet of building floor space were recommended. Their cost was estimated at \$13.4 million if located on one of three sites evaluated. A report has been written for publication and is now being processed through clearance channels.

2. Denver, Colorado. Field work is completed and a final report has been drafted which is now being reviewed. A public presentation of findings is tentatively scheduled for early November.

3. Honolulu, Hawaii. The study is completed and the report is published as MRR No. 821. Presentations of the results were made to State agencies, representatives of the University of Hawaii, the local food industry, and others interested in or who cooperated in the study. Improved facilities for distributing food in Honolulu and other counties in Hawaii could save between \$590,000 and \$654,000 each year, depending on financing arrangement. These facilities were estimated to cost \$3.6 million. Fort Armstrong is the site for the facilities, part of which have been constructed.

4. Dayton, Ohio. The study is completed and a report written which is in the process of publication.

5. Oakland, California. Field work is completed and a final report is being drafted. Presentations of the findings were made in Oakland in June to local

agency and industry groups. New facilities, covering about 74 acres, are estimated to cost \$12.5 million if located on one of four sites evaluated.

6. Salt Lake City, Utah. Field work is completed and a final report is in process of publication. A public presentation of the findings of the study was made. New facilities were recommended costing an estimated \$2.8 million. Five possible sites for the facilities were evaluated.

7. Los Angeles, California. Field work has begun on collecting data in a study to determine the need for improved food distribution facilities in the Los Angeles area. Some 1,200 local food firms are involved in the evaluation.

8. Minneapolis, Minnesota. Field work is completed and a final report has been written and presented. New facilities that would cost between \$1.5 and \$1.9 million were recommended.

9. Determine the most efficient and least costly system for supplying refrigeration to food complexes. The study is completed and a final report of the findings has been drafted. One central system proved to be the most economical to own and operate under the parameters of the investigations with individual unitary systems being the least economical. The report is being reviewed for publication.

10. Determine optimum product volume possible to handle and parking space needs of wholesale food centers. The study is completed. A final report has been drafted that shows optimum annual volumes that could be handled by various types of food wholesalers in given amounts of floor space supported by facility layouts and operational descriptions necessary to do so. The report is now being reviewed.

11. Preliminary and followup. Technical assistance was provided in:

a. Baltimore, Maryland. A 260-acre site was selected for the new food distribution facilities for Baltimore and some \$2.5 million in bonds were sold by the State of Maryland for site acquisition and preparation. These new facilities follow recommendations of an ARS study presented in MRR No. 783.

b. Boston, Mass. The New England Produce Center began operations this spring. In addition, construction is to begin soon on the \$8.5 million meat section located in South Boston. Thirty-two meat wholesalers from the old Faneuil Hall Market area will be located there. Two other developments of new marketing facilities are being planned. One involves the Boston Flower Exchange and the other the Atlantic Fish and Lobster Industries.

c. Chicago, Illinois. Space in the Chicago Food Center, billed as "the world's largest wholesale food center," are being leased. Sponsors of the \$250 million project are planning the facility to be located on 640 acres located at the North end of Lake Calumet. It will contain 6 million square feet building space for food warehousing, processing, and distribution.

Planned efficiencies in the new center are expected to save \$25 million each year in distributing food in the Chicago area. This new center follows recommendations of an ARS study presented in MRR No. 790.

d. Milwaukee, Wisconsin. One of three sites selected by market authority architects will be the location for the new fresh fruit and vegetable market in Milwaukee. Assistance is being provided the Division of Economic Development, Office of the Mayor, City of Milwaukee, and the State of Wisconsin Department of Agriculture at their request in evaluation of these sites. These agencies cooperated on the study conducted by the Marketing Facilities Development Branch, recommendations of which are outlined in MRR No. 664.

e. Minneapolis, Minnesota. Technical assistance was provided the architects planning new facilities for the Metropolitan Fresh Fruit Center for Minneapolis. This assistance, provided at the request of the architectural firm, consisted of technical review of plans for the purpose of suggesting improvements.

f. New York, New York. Additions planned for further development of the food distribution center at Hunts Point raise the total area of the site up to 367 acres and bring the total cost for the development above \$200 million. Assistance was provided the architect, city officials and planners in finalizing proposed additions to the Hunts Point development.

g. Pittsburgh, Pennsylvania. Pittsburgh produce wholesalers chartered a new corporation to be the instrument for establishing and operating their new market facilities. It will handle the building program, both prior to and during construction, and will integrate the functions of the local produce credit association and the trade relations committee. Assistance was provided planners and developers. Workshops were held with wholesalers to illustrate the most advanced equipment and efficient methods of operation.

h. Springfield, Massachusetts. The new Springfield Regional Food Market was dedicated and is now in operation. Technical assistance was provided architects in planning this new food center.

i. Washington, D. C. Construction is completed and new facilities occupied which house fresh fruit and vegetable wholesalers on the Union Terminal Market. Plans were reviewed by the Branch.

j. Raleigh, North Carolina. Plans for expanding the Raleigh State Farmers' Market were developed in cooperation with and at the request of the market.

k. Greenville, South Carolina. A master plan for current and future expansion of the Greenville Farmers' Wholesale Market was developed in cooperation with and at the request of the market.

l. Columbia, South Carolina. Plans for expanding the Columbia State Farmers' Market were developed in cooperation with and at the request of the market.

m. "20 Cities." Twenty-one existing food centers in 20 cities were studied for a report on "The Development and Operation of Wholesale Food Distribution Centers for Cities." This report is written and being reviewed for publication.

n. Benton Harbor, Michigan. Dedication of "the largest assembly market in the United States" will be held soon. These new facilities came about after an ARS study presented in MRR No. 390. Technical assistance was provided as requested during facility development.

o. Altoona, Pennsylvania. Preliminary investigation was made for a study of food distribution facilities in the Altoona area at the special request of the Economic Development Administration. In cooperation with EDA, Altoona Enterprises, Inc., and the local food industry of Altoona, a study was planned.

p. Determination of alternative types of construction for wholesale food facilities having different design features. Plans and arrangements were made to begin a study involving investigations to develop plans, specifications, and construction costs for multiple-occupancy buildings having different design features. Results will point up the most advantageous building design from the standpoint of economy in construction and layout.

q. International cooperation. At the request of the city of Johannesburg, Union of South Africa, consultations and technical guidance were provided planners of a new food distribution center for Johannesburg. Subsequent plans developed were reviewed and analyzed for the purpose of suggesting ideas for improvement. Similar assistance was provided other countries in developing improved food marketing facilities, including Japan, France, England, Dominican Republic, and Brazil. In Brazil, technical assistance and guidance is being provided in the development of central wholesale markets at Recife, Salvador, and Fortaleza. Modifications of previously developed plans for the Recife market are complete. The study and planning phase of the Salvador market has been completed, a site has been selected, and the State Government is in the process of acquiring land. In Fortaleza, a Development Advisory Council has been appointed and a contract negotiated for the development of plans and specifications for the market.

B. Producing Area Facilities

1. Poultry and eggs. Ten studies were made to develop improved layout and operation designs for facilities to market poultry and egg products. This included work in developing an experimental hot turkey cut-up line (the first of its kind) and also a design for the largest processing plant in the country for geese. All studies placed emphasis on establishing demonstration units that would act as a stimulus or guide to the industry of ways to improve facility and operation designs. Also, some support was provided the urban area facility study in Los Angeles.

2. Fruits and vegetables. Five studies were completed to develop improved facilities for marketing fresh fruits and vegetables. Another study was begun to determine the most effective facility and operation layout for a potato processing plant. Some effort in this field was in support of the urban area facility study in Los Angeles.
3. Food warehousing. Efforts in this field were coordinated with and supported the work of studies involving urban area facilities in Denver, Oakland, Honolulu, Los Angeles, Salt Lake City, Cincinnati, and Minneapolis, and also determining the most effective refrigeration system for food center complexes.
4. Dairy products. Three studies were made involving plant and operation layouts and designs for dairy product processing facilities. Also, a substantial portion of effort in this field was in support of the urban area facility study in Los Angeles.
5. Livestock and meat. Efforts in this field have been directed primarily to support the urban area facility studies in Denver and Los Angeles, which involves facilities for marketing livestock and meat. Also, a study was made to develop improved cattle and hog slaughtering operations.

Publications - USDA and Cooperative Program

Urban Area Facilities

- Crow, W. C. 1967. Paper presented at the opening of the Regional Food Market in Springfield, Massachusetts.
- Crow, W. C. 1968. Our basic success. Paper presented at State University of New York, Farmingdale, New York.
- Brasfield, K. H. 1968. The need and development of terminal wholesale food facilities. Paper presented at a public meeting in Cincinnati, Ohio.
- Taylor, E. G. 1968. Cincinnati wholesale food distribution facilities. Paper presented at a public presentation in Cincinnati, Ohio.
- Overheim, R. K. 1968. Honolulu wholesale food distribution facilities. Paper presented at a public presentation in Honolulu, Hawaii.
- Crow, W. C. 1968. What improved food marketing facilities mean to Boston consumers. Article for Boston Herald Traveler.
- Crow, W. C. 1968. Physical distribution of food. Article for Handling and Shipping Magazine.
- Boles, P. P. 1968. Improved food distribution facilities for Salt Lake City, Utah. Paper presented at a public presentation in Salt Lake City, Utah.
- Overheim, R. K. 1968. Oakland wholesale food distribution facilities. Paper presented at public presentation in Oakland, California.
- Overheim, R. K., and Boles, P. P. 1968. Wholesale food distribution facilities for Honolulu, Hawaii. Marketing Research Report No. 821.
- Crow, W. C. 1968. Another milestone in the parade of progress. Article for The Packer.

Producing Area Facilities

Crow, W. C. 1967. Improving physical distribution of poultry products.
USDA Poultry Seminar.

Crow, W. C. 1967. Paper presented to American Stock Yards Association,
Mayflower Hotel, Washington, D. C.

AREA 2

DAIRY PRODUCTS - MARKETING FACILITIES, EQUIPMENT AND METHODS

(RPA 505 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING LIVESTOCK)

USDA and Cooperative Program

Location of Intramural Work		Scientist Man-years FY 1968
<u>Milk</u>	Missouri	1.3
<u>Manufactured Dairy Products</u>	Maryland	<u>1/</u>
Total		1.3
<u>1/</u> No direct assignment of Branch personnel.		

Problems and Objectives

Fluid milk and manufactured dairy products are basic food items. Many of the plants involved in handling, processing or manufacturing milk, ice cream, cheese, butter and dried products from the approximately 115 billion pound raw milk supply are doing so in obsolete plants with relatively low labor productivity. A major contributing factor is the absence or piecemeal use of automated systems by the industry. This is due to lack of technical and engineering guidelines concerning suitable plant layout, types of equipment required, and the necessary controls for automation. Studies indicate that a fully automated plant can increase labor productivity 100 percent. Engineering research is needed to provide the dairy industry with data and guidelines on improved plant layout, equipment and automatic controls to increase operating efficiency.

Major objectives of the research are:

1. Based on current technology, to develop improved layouts and operating criteria for automated dairy product plants.
2. To design, construct and test improved equipment, devices and automated systems.

Progress - USDA and Cooperative Programs

A. Milk

1. Increasing Efficiency Through Optimum Utilization of Automation in Fluid Milk Plants. In cooperation with the Missouri Agricultural Experiment Station, at Columbia, experiments were continued using the University of Missouri dairy plant as a pilot plant for conducting research under production conditions. Labor requirements for the automated plant were collected. The following items of equipment were added to the processing line to improve efficiency: (1) A CIP booster pump; (2) a 2-speed centrifugal pump (low-speed for processing; high-speed for cleaning); and (3) a spray tube in the vacuum chamber. Data on the conductivity parameters for several chemical ingredients used in formulating detergents were obtained. These data will be used in evaluating detergent feeding (metering) devices for automated CIP cleaning systems. A method for evaluating the cleanliness of a stainless steel surface was determined and published. An experimental test stand was designed and constructed, and experiments are underway to determine the parameters for cold water cleaning of dairy plant equipment. During the year, a manuscript was prepared covering the circuitry and controls for a CIP flow-diversion valve assembly which permits complete CIP cleaning. This manuscript was in the publication process at the end of the year. Two other manuscripts were in draft form. One covers the design requirements of an automated CIP cleaning system and the second deals with design requirements of an automated fluid milk processing line capable of being completely CIP cleaned.

B. Manufactured Dairy Products

1. Layouts and Operating Criteria for Automated Dairy Product Plants.

Work on checking, reorganizing and rewriting three contract reports covering the development of layouts and operating criteria for different types of automated dairy product plants was completed during the report year. One manuscript dealing with cheddar cheese plants is in the publication process. The last two reports, one covering butter and dried milk products and one dealing with cottage cheese, cream cheese, and cultured milk and cream, were being typed for submission at the end of the year.

Publications - USDA and Cooperative Programs

Milk

Heinz, J. V., Marshall, R. T., and Anderson, M. E. 1967. Determining cleanliness of milk contact surfaces by analysis for calcium residual-- preliminary studies. Journal of Milk and Food Technology, 31:11, pp. 337-339.

Anderson, M. E. 1968. Automation of small fluid milk processing plants. A technical paper presented at the Nebraska Dairy Industry Conference, Lincoln, Nebr.

Anderson, M. E. 1968. Design requirements for an automated milk processing system. A technical paper presented at the Kansas Dairy Industry Conference, Manhattan, Kans.

Anderson, M. E. 1968. Automated cleaning of a fluid milk processing system. A technical paper presented at the Mid-Central Regional Meeting of the American Society of Agricultural Engineers, St. Joseph, Mo.

Anderson, M. E. 1968. Automated food processing systems. A technical paper presented at the Milk and Food Sanitation Conference, Columbia, Mo.

AREA 3

FIELD CROPS - MARKETING FACILITIES, EQUIPMENT AND METHODS

(RPA 504 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING FIELD CROPS)

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years FY 1968
<u>Cotton</u> California	1.1
<u>Cottonseed</u> Mississippi	1.1
<u>Corn</u> Indiana	2.1
<u>Wheat</u> Kansas	1.0
<u>Sorghum Grain</u> Kansas	0.2
<u>Rice</u> Texas	2.1
<u>Peanuts</u> Georgia Virginia	4.1 0.2
<u>Tobacco</u> North Carolina	1.1
Total	13.0

Intramural program is supplemented by extramural support representing (a) 1.2 SMY's at State Agricultural Experiment Stations, and (b) 4.1 SMY's at other U.S. institutions.

Problems and Objectives

Improved varieties of many field crops with their increased yields, along with progressive cultural and harvesting practices, require improved techniques and equipment for economically handling, conditioning and storing these crops in marketing channels. Grain now must be handled and conditioned in large quantities in a short period of time yet its quality must be maintained and labor and other costs minimized. Although product deterioration in storage has been reduced in recent years due to increased acceptance of aeration, shrinkage from loss of moisture is still a factor as well as loss from handling. Physical damage to the product must be reduced to maintain a high standard of quality. Because certain field crops are susceptible to contamination by toxin-producing molds, conditioning techniques and equipment must provide mold inhibiting environments.

Major objectives of this research are to:

1. Determine requirements essential to the development of improved techniques, equipment and facilities for conditioning, drying, storing and handling field crops.
2. Develop and test improved techniques and equipment for drying and storing field crops while maintaining desired standards of quality.
3. Develop and test improved techniques and equipment for the efficient handling of field crops yet minimize physical damage to the product.
4. Develop and test improved techniques and equipment to prepare field crops for market.
5. Establish design principles and improved facilities for commercial storage of field crops.

Progress - USDA and Cooperative Programs

A. Cotton

1. Handling and storing. At Bakersfield, Calif., a study has been completed on loading bales of cotton into van-type trucks and boxcars using low-mast free-lift clamp trucks. Results show one 4-bale clamp truck can load a van at a rate of 100 bales in 18 man-minutes and a boxcar in 14 man-minutes, a reduction of 28 and 14 minutes respectively from standard clamp trucks. A study completed on lease versus ownership of clamp trucks shows leasing is \$50 less for 1,000 hours, \$120 less for 3,000 hours, and \$225 less for 6,000 hours than ownership. Operating efficiency of this equipment is reduced 22-43 percent during the 6,000 hours of operation. Take-away conveyor operation at warehouse bale compress revised with new micro-switches and larger capacity pneumatic cylinders, resulted in reduction of crew size by 2 and less than 5 percent downtime. Studies on all-steel clear-span storage compartments show 28 gauge corrugated metal panels can be used in place of 18 gauge; reinforced doors can be made in 1 piece instead of 2 pieces; and bottom 4 inches of door in cement groove will resist up to 40 m.p.h. winds. Improved layouts were developed for storing compressed bales 2-high and flat

bales 3-high on head. Suggested height of compartment at ridge is 26 feet, height at eaves is 16 feet 8 inches. Exploratory studies were made on loading presently used cargotainers to determine feasibility of research on loading patterns, optimum size, cotton warehouse loading facilities needed, and equipment required.

2. Humidifying. At Bakersfield, Calif., laboratory tests on moisture regain in baled cotton measured the effect of four major variables; bale density, average moisture content, ambient temperature and humidity. Full-scale and pilot studies verified laboratory findings for moisture regain in stored baled cotton. Laboratory study shows average moisture content of bale may be estimated by measuring equilibrium temperature and humidity at a depth representing one-half of the bale volume. Study of humidity controllers shows low cost electronic humidistats superior to timeclocks. Humidity recorders, water meters, and effective maintenance program are essential in controlled humidified storages to protect bale quality. Design and operating criteria for humidification systems in storage compartments were prepared.

B. Cottonseed

1. Aerating and storing. In cooperation with the Mississippi Agricultural Experiment Station and its Delta Branch Station at Stoneville, Miss., cottonseed aeration studies were continued on improved systems in selected commercial storages. Studies showed improved systems produced uniform cooling, quality maintenance, and initial germination maintenance during storage. One storage was modified to use the unloading tunnel as the only aeration duct. Pipe arrangements provided for aerating a minimum of 1/4 of the storage at one time. Two fans, one at each end, aerated the entire storage, 2,400 tons, with a total of 15 horsepower. Cottonseed was cooled to 60° F. which effectively maintained the quality until seed moved out earlier than usual for cleaning and processing. No germination loss occurred during storage. Temperature distribution was relatively uniform with a range of 56° to 62° F. Due to a late harvest and shortage of seed, a 14,000-ton muskoguee-type storage was not completely filled with cottonseed and storage observations were limited. Only 408 hours of aeration occurred. The conical area having higher temperatures in the peak of the pile was not as pronounced this season as in previous years which may be due to less cottonseed and higher airflow. Design and construction information was furnished for 19 complete aeration systems to commercial companies in Mississippi, Georgia, Texas, Mexico, and Argentina.

2. Optimum storage conditions. In cooperation with the Mississippi Agricultural Experiment Station at State College and at the Delta Branch Station, the study was continued on determining environmental storage conditions necessary to minimize production of aflatoxins in cottonseed. Tests were conducted at the Delta Branch Station and sample analysis at State College. Gin run fuzzy cottonseed was rewetted to four initial moisture contents, 11, 14, 17, and 21 percent. Aerated and nonaerated test lots were used. Aeration rate was 0.14 c.f.m. per cu. ft. equivalent. Only one storage temperature of 80° F. $\pm 1^\circ$ was used. Storage period was 40 days with samples taken at 10-day intervals. All

test lots of cottonseed were inoculated with 6 isolates of Aspergillus by blowing spore air through them. The second test used a different initial lot of cottonseed. A preliminary report on sample analyses indicated the presence of B₁, B₂, and G₁ strains of aflatoxin in the aerated test lots having the two highest moisture contents of both test runs.

C. Corn

1. Drying and storing. In cooperation with the Purdue Agricultural Experiment Station, the studies continued at Lafayette, Ind., showed that partial drying of 30 percent moisture field-shelled corn to 20 percent with heat and finishing the drying with aeration was only partially successful. Aeration airflow rates of up to 1/2 c.f.m. per bushel were not adequate to lower the corn moisture to safe levels in time to prevent substantial mold growth. Aeration was continuous. Late harvest, poor quality of the crop, and excessive fine material in the corn undoubtedly contributed to the poor results. Corn field shelled at 32 percent moisture and stored under aeration was maintained in satisfactory condition for only about a week. Corn dried in commercial models of concurrent flow dryers was of acceptable quality when dried with air temperatures up to 300° F. Above this temperature the bulk density and the milling score was reduced substantially. In corn metering tests using fluted rolls a more even flow was obtained at low corn moisture levels, at high flow rates, and with the rolls rotating clockwise in a 60° hopper.

2. Storing high-moisture corn. Under a research cooperative agreement with the Kansas Agricultural Experiment Station, studies were continued at Manhattan on the storage of high-moisture corn. Representative samples of the field-shelled corn used in the laboratory and refrigerated storage tests were analyzed for extent of mechanical and physical damage to kernels. Visual and screen separations and classifications were made on each initial sample. Unsound kernels due to small or large cracks in the seed coat and endosperm were classified as mechanical or harvester damaged. Broken kernels were hand separated. Small pieces and fine material were separated by a 12/64-inch prescribed sieve. October field-shelled test corn averaged 26.7 percent moisture, 0.9 percent fine material, 6.7 percent broken kernels plus 8.6 percent cracked seed coats. November field-shelled test corn averaged 26.5 percent moisture, 2.5 percent fine material, 11.2 percent broken kernels, plus 11.8 percent cracked seed coats. Fungal infestation and mold development were first apparent on mechanically damaged corn kernels and showed in seed coat cracks down into the endosperm. Corn samples taken on the prescribed days during the cooling and storage tests were found to yield three principal molds, *Rhizopus*, *Penicillium* and *Mucor*. Up to 30 percent of kernels were infected with *Rhizopus* in the 25 percent moisture corn at 35° F. but reduced as the corn dried. *Penicillium* increased at cold temperatures as long as the corn was high moisture and reached 60 percent near the center of the 6 ft. depth bins. *Mucor* continued to develop at low temperatures and ranged up to 78 percent after 100 days of storage. Test corn contained no visible nor yielded any toxin producing molds.

D. Wheat

1. Reducing damage from handling. In cooperation with the Kansas Agricultural Experiment Station, at Manhattan, significant effects of variety, method of cutting, location, and year on internal physical damage to wheat kernels were observed. Many internal cracks in kernels already were formed in the field before harvest. Only radial cracks due to wetting and drying cycle were observed. A mechanism of crack formation in kernels were postulated. The average breaking strength of wheat kernels decreased linearly with increased internal damage. Frequency of breaking strength of kernels exhibited a normal distribution. An index for predicting or describing susceptibility to breakage of wheat kernels was defined. A linear relationship between index defined and percent internal damage was obtained. Mechanical damage of soybeans and corn at combines was examined. Breaking strengths of soybeans and corn kernels were evaluated. Significant effects of size, orientation, and moisture content of kernels on the breaking strength were observed. Studies on grain damage by the pneumatic conveying system were made with yellow corn samples to evaluate the effects of size and shape of kernels, air velocity, history of grain, and number of successive handlings on damage.

2. Aeration and drying. Also at Manhattan, Kans., studies were continued on the effectiveness of a two-fan, crossflow, ventilation system for conditioning high moisture, or tough, wheat. The two fans were controlled manually by the elevator operator or project personnel depending upon the test scheduled or seasonable weather conditions. The test bin at Abilene, Kans. was filled four different times with a total 1,000 bushels of new crop 1967 wheat. All four lots officially graded "tough." The first full bin was ventilated for two weeks starting July 1 for a total of 105 hours of fan operation. Averages from the moisture content sample test data indicated a reduction of 0.5 percentage points from 14.6 to the 14.1 percent. Recorded grain temperatures indicated cooling of 16.6° F. The second bin lot averaged 14.3 percent moisture, was held 10 days, ventilated for 135 hours resulting in moisture reduction of 0.2 percent and mean grain temperature reduction of 5° F. The third bin lot averaged 15.2 percent moisture, was held 16 days and ventilated for 232 hours. Representative grain temperatures were reduced 13° F.; the moisture content was reduced 1.4 percent to 13.8 percent. In August a fourth lot with moisture content averaging 13.7 percent was held for two weeks while the fans operated 135 hours. Average grain temperatures were reduced 10° F. and the final moisture content tested 12.8 percent. Tests of this one system over a 4-year period included 28 bins of grain, or more than 750,000 bushels, and the operation of the crossflow fans for over 3,000 hours.

Temperature variations of Hard Red Winter wheat stored in an 18-foot diameter bin with 100-foot grain depth without turning or aeration for 2 1/2-year period, have been analyzed. Variation in the vertical direction was practically negligible compared to that in the radial direction. Also changes in diurnal and annual ambient temperature can be represented as a periodic function of time. An analytical solution representing transient heat transfer within wheat stored in a concrete bin was derived from the Fourier heat conduction equation. Temperature distributions in the wheat as generated

by a derived solution agree well with corresponding actual temperature distributions. Differences in "lag" of temperatures between the ambient temperature distribution and grain temperature distributions increased almost linearly as the radial distance from the center of bin decreased. The analytical solution obtained should be useful in predicting grain temperature distribution, in effective scheduling of turning and mixing of grain, and in evaluating thermal diffusivity of grain for the case of transient heat transfer.

E. Sorghum Grain

1. Aeration. In cooperation with the Kansas Agricultural Experiment Station, a study of aeration of sorghum grain in commercial storages was continued at Manhattan. Analysis of data from tests were continued in an effort to explain the moisture loss factor for the grain and how it contributed to the overall weight loss or shrinkage. The important factors considered are (1) initial condition, grade, representative moisture content, mean temperature of grain; (2) location, seasonal weather conditions, time in storage; (3) size of storage units, upright or flat type storage and its structural material; (4) type and design of aeration equipment and airflow rate; (5) handling, transfer and turning equipment used; (6) control and operating schedules for unit fans or systems. On an annual basis with comparable variables, grain held in steel flat storage buildings or small metal bins is exposed to more solar energy and higher temperatures than grain in upright storages, thus causing a greater moisture loss. Aeration fans should be operated at night for dry grain, but continuously for wet tough grain.

F. Rice

1. Drying. In cooperation with the Texas Agricultural Experiment Station, rice drying studies were continued at Beaumont. Pilot-scale drying tests indicated that the drying rate increased as heated air velocity was increased in the range between 115 and 167 cubic feet per minute with no significant difference in milling yield of rice. High air velocities resulted in the removal of a considerable amount of chaff and other trash from sound rice. Laboratory tests were conducted to study the effect of various rice temperatures and air velocities on drying rate and milling yield when rice was heated in vapor tight containers, then cooled by forced ventilation. Drying rate was increased at higher rice temperatures before cooling and was reduced by cooling in shorter times with high air velocities. There was no significant effect of either rice temperature or cooling air velocity on the milling yield of rice samples. Tests on mixing equal amounts of rice at two different moisture contents indicated that although 75 percent of moisture equalization occurs within the first 48 hours, equalization was not complete within a 40-day period. Undried rice storage tests showed that aeration using refrigerated air at 65° F. maintained rice at grade No. 1 for 10 days compared with six days for rice aerated with ambient air at 82° F. Storage mold, A. flavus and aflatoxins were inhibited when rice was aerated with refrigerated air.

2. Handling rice at commercial dryers. Also at Beaumont, studies on handling rice during the drying operation at commercial dryers indicated that plant layout was a major factor affecting efficient operation. At some dryers changes in conveying equipment to allow simultaneous receiving, drying and shipping of rice were recommended. Partial loading of bucket elevators was a major bottleneck in rice handling operations. An ammeter at a remote location in the elevator motor circuit was effective to monitor loading. A photoelectric relay installed in an elevator boot to control the conveyor feeding the elevator aided in guarding against elevator choke-ups. The scalper, or cleaner, commonly installed above a drying unit's garner bin, was a bottleneck when trashy rice was handled. A bypass was designed to alleviate this problem. Proper use of the dryer-aeration process reduced the required number of passes for drying lots of rice. Tests on handling milled rice by a bucket elevator indicated no physical damage resulted from conveying. Various belt speeds for elevator tested showed maximum handling capacity occurred at 250 feet per minute.

G. Peanuts

1. Drying farmers stock peanuts. Drying tests were conducted on Spanish-, Runner-, and Virginia-type peanuts at Dawson, Ga., and on Virginia-type peanuts at Suffolk, Va. The air temperature was set at 115°, 130° or 145° F. in some studies, in others it was varied to maintain maximum peanut temperatures of either 95°, 105° and 115° F. Peanuts were exposed 15 and 30 minutes with about 4 hours of aeration between exposures. Spanish peanuts in tests using set air temperatures shelled better than those where maximum peanut temperatures were maintained, with splits ranging from 6 to 10 percent. Split kernel outturn of Runner-type peanuts was less than 4 percent. At Dawson, considerable sensitivity to temperature was shown by Florigiant peanuts--higher temperature tests yielding more split kernels. Tests at Suffolk on 56R peanuts indicated less sensitivity to temperature than Florigiant. All heated-air tests showed no aflatoxin in dried peanuts. Drying tests were run using freshly dug peanuts and low-temperature air (40° and 60° F.) with airflow rates of 5 and 10 c.f.m. per cubic foot of peanuts. Milling quality of Spanish- and Runner-types was poorer but Florigiant-type better than for peanuts dried with heated air. More split kernels resulted from using 60° F. than from 40° F. air. Flavor inferior to ambient air dried peanuts was noted. Fatty acid content was high in many low-temperature tests. Traces of aflatoxin were found in peanuts from only 2 of 24 tests. Drying required from 7 to 25 days.

2. Shelling farmers stock peanuts. At Albany, Ga., a study was completed and a manuscript prepared on the performance of four commercial peanut shellers relating sheller speed, grate size and bar design to shelling rate, efficiency and whole kernel outturn for Runner-, Spanish-, and Virginia-type peanuts. The average pod size, measured in 64th's inches, was 27.5, 27.0 and 35.0 for 1967 crop Runner-, Spanish-, and Virginia-type peanuts, respectively. Average minimum kernel size was 18.5, 18.5 and 20.0. Average minimum space between kernel and hull was 3.0, 4.5 and 10.4. Preliminary size groupings were

obtained for presizing the three types of peanuts. Shelling tests were conducted to determine advantages of presizing Spanish-type peanuts by pod size. Results show that the three size groupings gave no advantage over current shelling methods. A laboratory peanut sheller (Medley type) having a capacity of 500-1,000 pounds per hour was developed. Sample size for reliable results should exceed 20 pounds. This sheller measures changes in milling quality of peanuts and correlates with pilot plant sheller. A new principle of separating split and whole peanut kernels was developed and equipment designed to make grades of split and whole kernels having the same physical size. Also has possible use as a blender. Capacity of laboratory model is 500 pounds per hour minimum.

3. Handling. At Albany, Ga., handling farmers stock peanuts with bucket elevators of two different sizes was investigated. Belt speeds ranged from 140 to 420 f.p.m. Maximum rates achieved were 22 tons per hour with 9- by 5 1/2-inch cups on 6-inch spacing and 8 tons per hour with 4- by 6-inch cups on 8 1/2-inch spacing at belt speeds of 280 and 400 f.p.m. respectively for both Runner- and Spanish-type. Rates were somewhat less with Virginia-type. Tests showed foreign material affects cup loading. Handling rates at times exceeded theoretical rates due to mounding of peanuts in cups. Mechanical damage data (split kernels plus loose shelled kernels) showed no significant increase at any belt speed. There was some indication that smaller bucket elevator cups damaged Virginia-type peanuts more than other types due primarily to cups not having sufficient clearance. This clearance also reduced handling rates. Mechanical damage to peanuts increased about 1 percent for every seven passes through the elevator. Comparing final damage to initial condition indicates bucket elevators cause less damage to farmers stock peanuts than other methods and practices used in combining, drying, cleaning, and moving into and out of storage.

H. Tobacco

1. Handling tobacco at auction warehouses. In cooperation with the North Carolina Agricultural Experiment Station, through research conducted at Raleigh, a system was developed for receiving tobacco at auction warehouses using a 10-man crew, with each crew member assigned specific responsibilities. The system; which uses gravity roller conveyors, costing about \$1,000; and forklifts renting for \$225 a month was installed and used commercially by Carolina Warehouse at Fuquay, and Centre Brick Warehouse at Wilson, to receive all their loose leaf tobacco during the 1967 marketing season. During the second year of operation the experimental grading and sales line at Fuquay was redesigned to eliminate storage between weighing and grading. Each operation was designed for a 6-second interval to provide the buyers with 10 baskets a minute. Thirty-six baskets were scheduled through the system each sales day with the maximum limited to 50 baskets because of length of loadout line. This experimental system was operated each sale's day between Sept. 7 and Nov. 21, for 6-10 percent of the selling time allotted to the warehouse. Fifty-seven growers sold 180,293 pounds of tobacco using the system during this period.

2. Storing unprocessed tobacco. Under a research cooperative agreement with the North Carolina Agricultural Experiment Station, about 2,000 pounds of flue-cured tobacco was acquired from Reidsville and 200 pounds from Whiteville research stations in October and November for research on conditions required for holding the tobacco until the following marketing season. In November and December the tobacco was divided into 11 lots of approximately 200 pounds (100 sticks) each, and placed in a typical farm "packhouse." Eleven samples with varying moisture contents were covered with one of two covering materials (burlap or polyethylene). Inspection of storage samples in late April showed slight mold growth on two samples. These samples and others covered with polyethylene were uncovered to allow for drying on outer edges where moisture had accumulated. No water droplets were visible. Outer layer was soft and pliable indicating moisture migration due probably to temperature fluctuation. Current indications are that if polyethylene is used over stored tobacco it should be removed in early spring, even when tobacco is stored at moisture contents as low as 11 percent. No insect infestations have been noted to date.

I. Grain

1. Effect of handling equipment. Under a research contract with Cargill, Inc., tests were continued to study the extent and causes of physical damage to grain by handling equipment used in commercial facilities. About 80 percent of the scheduled tests are complete. Corn was more subject to damage than wheat, soybeans or pea beans. Breakage resulting from a free drop of 100 feet was only 0.3 percent in wheat but ranged up to 13.8 percent in corn. Free drop of 100 feet caused 7-10 times more breakage in corn than caused by a bucket elevator or a grain thrower as they are normally used. In soybean tests, the breakage increased from 1.2 to 4.1 percent as free drop heights were increased from 40 to 100 feet. Dropping on concrete caused 50 percent more breakage than dropping on other soybeans. Dropping through a spout resulted in less breakage than free fall in an open stream. Also, there was less breakage in free fall from a 12-inch discharge than from an 8-inch discharge, a result which was unexpected. With bucket elevators, the damage increased with increased belt speed, but there was no difference between front and back feeding. Breakage was greater in soybeans at lower moisture levels and at lower temperatures.

2. Dynamic and static pressure phenomena in stored grain. Under a research contract with Dr. J. D. Isaacson, St. Louis, Mo., investigations continued on developing a basic theory of static and dynamic pressure phenomena in grain under storage conditions. With constant parameters except the varying wall-friction to study wall vibrations under dynamic conditions, the lateral pressure was 1.3 of normal static at midheight, and 1.6 at bottom of bin under normal friction conditions and nearly identical to pressures from low static friction conditions. Varying the ratio-function produced excessive dynamic lateral pressures in the upper two-thirds of the wall and a sharp increase in the lowest third. Study shows solving problems of grain pressures should be directed toward using numerical methods and digital computers.

3. Uniformly blending seed. Under a research cooperative agreement with the Mississippi Agricultural Experiment Station, the study was continued at State College on uniformly blending seed lots. The center-of-sidewall device was tested using layers of various colored plastic particles. Results showed three passes through the bin produced acceptable blending. Blending free-flowing seed having dissimilar physical characteristics (corn and grain sorghum) was tested with three of the devices. Five passes did not produce an acceptable blend. Separation occurred during free fall. Tests to blend a small amount of weed seed into sorghum showed three passes resulted in an average 26 weed seed per pound of sorghum rather than the theoretical 22.5.

Publications - USDA and Cooperative Programs

Cottonseed

Smith, L. L. 1968. Cottonseed storage and aeration in commercial facilities. Mississippi Agricultural Experiment Station, 81st Annual Report.

Corn

Thompson, R. A. and Foster, G. H. 1967. Dryeration--high speed drying with delayed aeration cooling. ASAE Winter Meeting.

McKenzie, B. A., Foster, G. H., Mayes, R. T. and Thompson, R. A. 1967. Dryeration--better corn quality with high speed drying. Cooperative Extension Service AE72. Purdue University.

Grain Sorghum

Hutchison, R. S. and Holman, L. E. 1968. Fan ventilation of air space above grain in flat storages. ARS 52-27.

Rice

Louvier, F. J. and Calderwood, D. L. 1968. Drying and handling rice at commercial dryers. The Rice Journal.

Louvier, F. J. 1968. Damage to milled rice during simulated bulk handling. The Rice Journal.

Louvier, F. J. 1968. Studies of handling procedures at commercial rice dryers. Proceedings Rice Technical Group, New Orleans, La.

Calderwood, D. L. 1968. Effect of varying air velocity in a continuous flow dryer. The Rice Journal.

Calderwood, D. L. 1968. Storage of undried rice in aerated bins. The Rice Journal.

Calderwood, D. L. and Schroeder, H. W. 1968. Aflatoxin development and grade of undried rice following prolonged storage in aerated bins. ARS 52-26.

Tobacco

Graves, A. H. 1968. Handling tobacco in warehouses. N. C. State Agricultural Experiment Station. Annual Report.

AREA 4

HORTICULTURAL CROPS - MARKETING FACILITIES, EQUIPMENT AND METHODS

(RPA 503 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING HORTICULTURAL CROPS)

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years FY 1968
<u>Citrus fruits</u>	
Florida	0.8
Georgia	.2
<u>Deciduous fruits and tree nuts</u>	
Georgia	1.7
Washington	2.2
<u>Potatoes</u>	
Minnesota	2.2
Maine	1.2
Florida	.1
Maryland	.2
<u>Vegetables</u>	
Florida	1.3
Georgia	.3
Total	10.2

Intramural program is supplemented by extramural support representing 1.2 SMY's at State Agricultural Experiment Stations.

Problems and Objectives

Returns to producers and prices paid by consumers for horticultural crops are adversely affected by the use of inefficient marketing facilities, equipment and methods. Better work methods, techniques, devices, operating procedures, equipment, and facilities are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing potatoes, citrus fruits, deciduous fruits, vegetables, nuts, and other horticultural crops. Such improvements at shipping points would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing cost, expand consumption, and reflect greater returns to producers.

Major objectives of the research on methods, equipment, and facilities for horticultural crops are to:

1. Reduce labor and costs for handling, storage, and packing.
2. Protect products and provide optimum conditions for commercial storage.
3. Develop improved cooling, conditioning, and storage techniques and procedures.

Progress - USDA and Cooperative Programs

A. Citrus Fruits

1. Handling, Degreening, and Packing. This research, in cooperation with the Florida Agricultural Experiment Station at Gainesville, is directed toward developing improved methods, devices, equipment, and facilities for conditioning, handling, and packing citrus fruit at shipping points. Data on photoelectric color sorting of citrus fruit were analyzed and a manuscript written. In 7 tests on degreening of oranges sorted into 4 color groups, greenest fruit took from 1 to 2 days longer to degreen than yellowest fruit. Amount of fruit degreened at given time different for each of the four groups. Some significant differences were found in internal quality factors between color groups at specific times during season. Significant increase in decay was found with increased degreening time. Initial fruit color and decay were not related. Washing fruit improved uniformity of color sort and did not hinder degreening. Hamlin, Valencia, and Temple oranges and limes sorted successfully into uniform color groups for better market appeal. Photoelectric color sorter could sort out fruit with large surface defects but not small ones.

Initial analysis showed that a fully automatic bagging machine costing \$20,000, using one-third time of an attendant, must replace more than four semiautomatic machines costing total of \$8,000, using one operator each for filling and closing, to save at least \$1,000 per year; ownership cost based on 10-year life for equipment; labor at \$1.60 per man-hour. Data on commercial trial of a 14-head, weigh mechanism, semiautomatic bag-filling machine

showed a production rate of 40 5-pound poly film bags per minute with two workers checking bag weight and automatic bag hanging and closing units attached. Saving of at least \$1,000 per year indicated for this machine versus current count-mechanism, semiautomatic machines, for annual volume of one million 5-pound poly film bags. Weigh machine for poly net bags required 4 workers; count-mechanism machine usable for net bags needed same size crew. Experimental channel-type bag-filling device was modified and tested. Test showed this low-cost device can be used to do both bag-filling and machine-assisted place packing. Contacts made with equipment manufacturers on mechanizing master cartoning of bagged fruit. Laboratory-scale test of 200-watt unit showed ultrasonic cleaning ineffective on oranges and grapefruit.

Manuscript was written on, "Modernizing Handling Systems for Florida Citrus Fruit--Picking to Packing Line;" to supersede MRR No. 529, "Handling Florida Oranges in Pallet Boxes," April 1962. Possible saving with pallet box over field box system is \$45,000 for annual volume of 500,000 field boxes rather than \$23,400 shown in MRR No. 529. For comparable volume, full bulk system offers savings of \$42,000. Same savings potential for modified bulk as for pallet box system not considering presizing and pregrading which can be conveniently incorporated in the modified bulk and also the full bulk system. Cost per pallet box essentially the same using either boom-type lift or tractor forklift for grove operations. Slatted, metal-bound, wood pallet boxes have shown good performance relative to their cost, in Florida. Some trouble with metal bands loosening. Plywood boxes, recently made available in the Florida citrus area, put in use for part of needs of several packing-houses. Insufficient data for comparison of maintenance costs for the two types of boxes. From limited use of straddle trailer in pallet box system in Florida, studies indicate potential savings for this equipment, over flat-bed semitrailers, when distance of one-way haul less than 11 miles. At 5 miles the indicated saving is 2.8 cents per field box equivalent. A device was developed for attaching to pallet boxes to count cycles of use by actuation in the dumping operation. This is a low-cost device for gathering data on the useful life of pallet boxes.

2. Cooling. At Orlando, Fla., and Athens, Ga., research on thermal properties and heat transfer characteristics was continued by further revision of a manuscript for a technical bulletin entitled "Thermal Properties and Heat Transfer Characteristics of Marsh Grapefruit."

At Gainesville, Fla., the report on a study of the performance of an experimental forced-air precooler at the University of Florida Campus Packinghouse with Florida citrus was edited for publication as a marketing research report. The manuscript now has the title "Experimental Forced-Air Precooling of Florida Citrus."

A manuscript was written on, "Forced-Air Precooling Citrus Fruit on a Moving Conveyor." Cooling air temperature can be well below fruit freezing point under controlled conditions without injuring the fruit. Fruit was at 85° F.

for container tests. Temperature data obtained as mass average showed mean temperature reduction in 30 minutes for Valencia, Pineapple and Temple oranges and Duncan grapefruit was 33° F. in open cartons and 38° F. in open crates; closing containers halved cooling rate. Temperature was reduced 40° F. in 30 minutes for fruit in poly net bags. Comparable cooling in poly film bags took 45 minutes. Temperature reduction of Valencia oranges in bulk was 22° and 16° F. for sizes 324 and 126, respectively, in 20 minutes from 80° and required 1 watt-hour per pound per degree F.

B. Deciduous Fruits and Tree Nuts

1. Handling and Packing Apples and Peaches. At Wenatchee, Wash., major changes were made in the prototype brush-roll sorting and sizing line for apples. Commercial runs with the unit indicated that the sorting, polishing, and packing operations were performed at a level equal to or greater than that for existing grading lines. Sizing was satisfactory, except for size 88 and larger. Because of machine design it was not possible to separate the brushes sufficiently to properly size these large apples. Sorters preferred grading fruit on brush-rolls, and after packers gained experience they preferred packing from the return-flow belt. A major problem was the "jamming-up" of fruit of one size in the let-down system associated with the sizer component. At the end of the packing season extensive modifications were made in the unit to eliminate defects. Results of tests on this machine indicate that its low incidence of bruising may at last permit packinghouse operators to pregrade their fruit without suffering the damage that occurs with existing equipment.

The manuscript "An Evaluation of Electronic Color Sorting of Apples" was completed. Only two electronic color sorters have been in operation in apple areas of the Pacific Northwest (only one during 1967-1968 season), and packinghouse operators generally have had little opportunity to observe and study their operation. This report describes the machine and its operation, and discusses its relationship to other packinghouse operations. The major finding was that the electronic color sorter, at its present cost and limited function, cannot be economically justified for the great majority of apple packinghouses.

At East Lansing, Mich., research was continued under a research contract with Michigan State University on the development of a hydrohandling system for prestorage sorting and sizing of apples. Under an amendment to the contract specified modifications were made in the prototype system, installed at a commercial apple packing and storage house at Belding, Mich., and tests of the modified system were conducted. During the 1967 harvest, runs were made with the prototype system using orchard-run apples which were received in pallet boxes of approximately 20-bushel capacity, emptied, sorted, sized, and filled back into pallet boxes--McIntosh, Jonathan, and Delicious varieties were included. Tests involved evaluation of mechanical damage, factors affecting the decay of apples stored in controlled atmosphere, and sizing efficiency. Preliminary results of these tests indicate that the

hydrohandling system will be satisfactory for Jonathan, Delicious and other "hard" varieties, but not for the tender McIntosh variety. Mechanical damage, evaluated after a storage period, indicated that additional developmental work will be necessary to provide sufficiently gentle handling before pre-storage sorting and sizing will be acceptable for the McIntosh variety.

At Athens, Ga., in cooperation with the State Agricultural Experiment Station, the study to evaluate existing methods of performing peach packinghouse operations was continued. A comprehensive analysis and evaluation of existing methods of making up packing materials and supplying them to the packing line was completed. Additional data on labor and equipment requirements for the grading and filling operations were obtained to supplement that obtained in previous years. Previous work under this project showed that pallet box handling of peaches is economically feasible, but it pointed out the need for improved pallet box dumping equipment that could be economically adapted to a low-volume (200 - 400 bushels per hour) operation. A study to design, develop, and test an improved pallet box dumper was initiated. A dumper was designed and a quarter-scale prototype constructed and tested. Results of preliminary tests justify construction of a full-scale model for installation and testing in a commercial packinghouse. Acquisition of materials and supplies for construction was initiated. A manuscript entitled "Handling Peaches in Pallet Boxes" was prepared for publication.

2. Storage of Apples. This area of work at Wenatchee, Wash., involves: (1) Investigations of airflow distribution methods, patterns, and rates in refrigerated fruit storages to determine and evaluate the influence of these factors on cooling fruit and bringing it to optimum storage temperatures; (2) determining and evaluating heat gain through various structural features of fruit storages as a basis for improving designs; (3) redesigning storage houses for the most efficient handling and storage of fruit in pallet boxes; (4) evaluating the hydrocooling of apples before they are placed in storage; and (5) developing improved methods, techniques, equipment, and facilities for controlled atmosphere (C.A.) storage of apples.

Writing was initiated on the manuscript, "Guide for the Cold Storage of Apples and Other Fruit," which will supersede and update Circular No. 740, "Cold Storages for Apples and Pears."

Studies showed that hydrocooling apples at harvesttime has no advantage over room cooling so long as cooling is accomplished in 7 days or less. However, where room refrigeration equipment is overloaded, hydrocooling greatly assists in removal of field heat and reduces total cooling load. Research was completed and a manuscript prepared on "Effects of Hydrocooling on the Dessert Quality and Storage Life of Apples in the Pacific Northwest."

Further observations of commercial controlled atmosphere storage rooms indicates that for airtight C.A. rooms lime scrubbing of CO₂ from the air is becoming more popular. Some storages use the Tectrol system for original pull down, then convert to lime or caustic soda scrubbing.

3. Cooling Deciduous Fruits. At Wenatchee, Wash., writing and preliminary editing of the manuscript on "The Effect of Vent Holes on the Cooling Rate of Fiberboard Boxes" was completed. Findings indicate that the cooling time of packed fruit in fiberboard boxes can be reduced over 50 percent by the addition of enlarged vent holes in the neutral stress areas of the ends of the boxes. These holes do not weaken the box to any great extent. Other studies indicate that regular fiberboard boxes will permit picked fruit to cool satisfactorily when there is adequate air circulation and sufficient refrigeration to remove the heat from the apples rapidly. Air temperatures in the room should be held at 30° to 32° F. for most varieties of apples, the air circulation should be not less than 1,500 c.f.m. per ton of refrigeration, and relative humidity in the room maintained between 85 and 90 percent.

At Athens, Ga., research carried out by the Georgia Agricultural Experiment Stations under a cooperative agreement utilized the Division's prototype forced-air precooler to: (1) Evaluate its performance; (2) investigate cooling effectiveness of apples, strawberries and peaches in relation to system performance; and (3) develop mathematical expressions of heat transfer with respect to product properties and configurations.

Average surface heat transfer coefficients of potatoes and plastic spheres in bulk lots were experimentally evaluated during cooling in the prototype forced-air precooler. From these data, correlations of Nusselt Numbers to Reynolds Numbers at the top, center, and bottom of a 14-inch deep bed of potatoes were computed for use in future design work on commercial forced-air precooling systems. Specially constructed bulk boxes with a capacity of approximately 400 lbs. of peaches or potatoes were filled to one-fourth, one-half, and full load capacity and cooled for periods of one-half hour and one hour, each at approach air velocities of 225 and 375 feet per minute. Cooling rate was evaluated by means of the slope of the time-temperature response curve, converted to logarithms for linearity. Cooling rate was influenced by produce load and air velocity, but to a lesser extent for the one hour period than for the one-half hour period. Cooling rate was generally higher at the half hour period with the higher air velocity, achieving maximum efficiency with the box fully loaded at this condition. Based on refrigerating capacity available, efficiency was 70 percent. Average cooling rate for a typical period of one hour was 0.66 degree F. per minute at the high air velocity.

A manuscript, "Heat Transfer Properties and Characteristics That Affect the Design of Precooling Systems for Apples," has been drafted.

4. Handling, Conditioning, and Shelling Pecans. Research at Athens, Ga., in cooperation with the State Agricultural Experiment Stations, on the conditioning, cracking, and shelling of pecans was continued. Stuart pecans were conditioned by soaking them in water at selected temperatures and steaming them at selected pressures. Changes in moisture content of the pecan kernels and the percent of whole halves obtained in cracking and shelling with commercial equipment were determined for each treatment.

Conditioning pecans before cracking and shelling by soaking, or steaming, resulted in approximately 35 percent more whole halves than was obtained for similar unconditioned nuts. There was no significant difference in the yield of halves between the two treatments but steam offers distinct advantages for potential commercial application. Pecans steamed for 5 minutes yielded approximately the same percentage of halves as pecans soaked for 2 hours then held for 12 hours before cracking. In addition to being faster, the steam treatment did not increase the moisture content of the kernels as much as the soaking treatment. The advantage of obtaining a higher yield of halves at a lower moisture content is that less moisture would have to be removed by drying prior to shipment. Moisture content of the shell, as well as of the kernel, will be evaluated in future studies of this type.

C. Potatoes

1. Handling and Packing Potatoes. Research at Presque Isle, Me., in cooperation with the Maine Agricultural Experiment Station, involves the development of more efficient work methods, operating procedures, equipment, and facilities for handling, storing, and preparing potatoes for market.

Joint work was continued on preparation of the manuscript, "Supplying the Packing Line with Potatoes in Maine Storages at Rates of 200 Hundredweights Per Hour and Above."

Under a research cooperative agreement, the Maine Station continued work on the design and construction of an improved sizer for "long" white potatoes. A number of modifications were made in the prototype potato sizer after it was moved from Orono to Presque Isle, including the installation of modified expanding rubber rolls on two lanes. The other two lanes still have wood rolls. Further modification and tests will be necessary to provide the basis for a design suitable for commercial use.

Under a second research agreement, the Maine Station continued research on designing and testing hydraulic handling systems for potatoes and other crops. Difficulties were encountered during tests with the closed system using a jet injector and, as a result, modifications were made which permitted tests to be performed at steady state conditions. Data were gathered on flow characteristics of potatoes in a 200-foot long, 8-inch bottom width trapezoidal flume. The test flumes were modified to provide a 10-inch bottom width. Rectangular metal sections to form 200 feet of flume were fabricated. Trials were conducted with this open channel rectangular cross section flume. Runs were completed and data assembled, but not analyzed.

Research at Gainesville, Fla., in cooperation with the State Agricultural Experiment Station, involves development of more efficient work methods, operating procedures, and equipment for the handling and preparation for market of potatoes in spring-crop areas. In a Hastings area packinghouse a new semiautomatic machine for filling 50- and 100-pound bags, which used a sewing machine to close the burlap bags, was time studied and bag weight

data were obtained. Analysis of cost reduction potential for new filling machine was incomplete, but indicates three workers produce 8 to 9 filled and closed 100-pound bags per minute in continuous operation. Additional data on weighing accuracy and delay caused by sewing machine are needed. Earlier data on manual filling and weighing and hand sewing indicate 1.5 to 2 times as much labor required as for the machine filling and sewing method. However, this efficiency would be offset in part by costs of semiautomatic filling and weighing machine at \$11,000; sewing machine at \$2,500. Possible application of commercially made photoelectric equipment for sorting potatoes for surface defects followed up. Consultation with equipment manufacturer shows equipment with required capability not yet available.

At East Grand Forks, in cooperation with the Minnesota and North Dakota Stations, work involves developing more efficient work methods, techniques, devices, and equipment for the handling and preparation for market of mid-western fall-crop potatoes. Work was completed on manuscript, "Handling Potatoes from the Storage to the Packing Line," covering 42,000, 60,000 and 120,000 cwt. storages using fluming, forking to conveyors, and bulk scooping systems at per hour rates of 100, 200, and 300 cwt. and the maximum rates for individual systems. Powered bulk scoop operations were analyzed relative to storage size, bin size and arrangement, hopper location, travel distance, and scoop performance. Optimum bin size-bin arrangement-hopper location-storage size combinations have been worked out for several 30,000 to 400,000 cwt. storages. A new proposed technique using fully movable hoppers increases powered bulk scooping capacity for trips greater than 50 feet and possibly will double output at distances greater than 150 feet. Several commercial packinghouse layouts were analyzed for process flow, operations and efficiency. Preliminary plans were developed for future packinghouse, packing and storage systems and layouts. Research was continued on the impact of cleaning and sizing fall-crop potatoes before storage. Sampling data of potatoes taken from a 120 cwt. bulk truckload indicated a normal tuber size distribution if allowance was made for tubers under 1.5 inches in diameter eliminated by the harvester. A 113 tuber (50-pound) sample resulted in a standard error of the mean of about .05 inch. Completed compilation of data on ring and tube hand sizing accuracies. Found no statistically significant method differences. Actual observations by different workers were significant. Outline for manuscript concerning the feasibility of sizing into storage partially developed.

2. Storage. Storage research at the Red River Valley Potato Research Center, East Grand Forks, involves providing optimum storage conditions for fall-crop potatoes for table stock, seed, and processing; and developing improved layouts and designs for potato storage houses.

Research to develop improved designs for above-ground potato storage for the fall-crop area was completed. Plans and specifications for a 60,000 cwt. cross alley potato storage were published. Completed design, drafting and specifications for 25,000 cwt. pallet box potato storage, the final set of four plans and specifications to be developed for storages for potatoes.

Drafted manuscript, "Bin Fronts for Potato Storages," pertaining to 20-foot spans. Revised and updated manuscript "Fall Crop Storage and Handling of White Potatoes."

Research on providing optimum conditions for the storage of potatoes for processing was continued. Selected temperature centroid, isotherms, temperature differences, temperature difference ratios, and mean and standard deviation as methods for representing and analyzing storage temperatures. Completed system design and instrumentation on two stage, direct expansion refrigeration system to be tested at low temperature and high humidity conditions.

At Presque Isle, Me., studies were conducted on airflow patterns in mechanically ventilated bulk potato piles. The duct configurations investigated were rectangular and triangular shaped center ducts and triangular shaped side ducts. The rates of supply air were 0.75, 1.0, and 1.25 c.f.m./cwt. The low air velocities in the potato pile were sensed with a specially designed airflow meter, constructed with paired thermistors in its circuit. The triangular shaped ducts produce no distinct difference in airflow patterns from rectangular ducts as the air passed through or emerged from the top of the potato pile. Since airflow rates are considered to influence weight loss and pressure bruising, a statistical analysis of weight loss versus pressure bruise index was initiated. Incidence of weight loss, pressure bruising, and internal black spot of tubers as affected by levels of relative humidity at a constant 45° F. temperature were studied. Two potato varieties, Russet Burbank and Norland, were selected for the study. The potatoes were subject to pressure levels of 150, 350, and 500 pounds ft.². The levels of relative humidity were controlled at 99, 88, and 79 percent. The tubers were removed from storage after 6 months and evaluated for injury based on U.S. No. 1 and 2 grades. Analysis of the data was not complete at the end of the report year.

D. Vegetables

1. Handling and Packing. In cooperation with the Florida Agricultural Experiment Station at Gainesville, research on handling and packing vegetables involves the development of improved work methods, devices, and operational procedures for the handling and preparation for market of vegetables at Florida shipping points.

Manuscripts were completed on mechanically sizing and centrally packing celery. Accuracy of the electronic scale was ± 0.058 pounds compared with ± 0.088 pounds for the mechanical beam type and ± 0.394 pounds for the hand sizing method. The central packing system required 40 percent fewer workers than the field packing method and reduced labor and equipment costs by 18.4 cents per crate. Data obtained on carrot packing show labor requirements were 0.142 man-minutes for one pound and 0.208 man-minutes for two-pound packages. Data analysis of overweight packages indicates a daily product loss of almost 18,000 one-pound packages in an average packinghouse.

Preliminary data on vine-ripened tomato weights and diameters indicate a range of 19 to 22 pounds for a 20-pound carton with random selection of a predetermined number of fruit within a size category. Data on photoelectric color sorting of tomatoes were analyzed and a manuscript was drafted. The optimum wavelength combination for measuring color at varying levels of maturity by light reflectance was 540-590 nanometers. Machine sorting was satisfactory except in sorting green fruit from those with a slight color break. Data showed a significant difference in color between four groups after sorting. Differences were smaller as fruit ripened, with little difference after 6 or 7 days. In work on development of improved photoelectric sorting equipment, spectral reflectance curves for various products were obtained and information on photocells and fiber optic units was compiled.

Research conducted by the Florida Station under a cooperative agreement to develop design principles for a mechanical celery stripper was limited to exploration of possible approaches and providing a basis for future work. Celery was obtained directly from the field with the outer petioles still intact and the stalks were dropped from heights of 5 feet and 6 feet through a 12-inch tube onto a metal plate. With a 5-foot drop, petiole removal was not effective. A 6-foot drop did not give effective petiole removal and stalk damage became noticeable. Only a few petioles were removed in total and, in most cases, none were removed from a stalk of celery. From the drop tests, it was concluded that another approach would be required to obtain satisfactory removal of the unmarketable outer petioles. In another test celery stalks were tumbled in a barrel-shaped chamber. This showed no results which would justify further research effort in this direction. One small-scale test, with a hand-held knife, did show promise for effective petiole removal, however. This involved progressively cutting off the butt end of the stalk to a depth sufficient to free the unwanted petioles. Further work will be done to construct an experimental unit to test this concept for development of an automatic machine.

Recent developments in the production and harvesting of tomatoes, such as mechanical harvesting for processing, has brought about an urgent need for the development of larger containers than field boxes for handling this commodity. Research on handling and ripening tomatoes in pallet boxes was undertaken and completed at East Lansing under a cooperative agreement with the Michigan Agricultural Experiment Station. Results of this research were published in Marketing Research Report No. 802, "Handling Tomatoes in Pallet Boxes."

Research designed to increase the efficiency and reduce the unit cost of handling, curing, storing, and preparation for market of sweetpotatoes and to minimize losses from spoilage and deterioration was conducted at Raleigh under a cooperative agreement with the North Carolina Agricultural Experiment Station and the North Carolina State Department of Agriculture. During the report period effort was confined to editing the manuscript, "Optimum Lowest Cost Sweetpotato Harvesting and Handling Systems."

2. Cooling. This research is designed to develop improved methods, operating practices, and techniques for use in existing and new facilities for more efficient cooling of vegetables.

At Athens, Ga., laboratory apparatus was put into operation and calibrated to relate fan speed with volume rate of airflow. Shapes of acrylic plastic were prepared for use in evaluating heat transfer coefficients. Tests to determine the effect of air temperature and flow rate of appearance and time-temperature response of sweet corn were carried out. Treatments included air at 0° F., 10° F., and 20° F. at velocities of 400, 830, and 1220 feet per minute. One ear of corn with the husk on and one ear with the husk removed and wrapped in thin polyethylene were subjected to the same treatment. The mass-average temperature of corn in air at 0° F. and 400 feet per minute reduced from 70° F. to 40° F. in 20 minutes and to 35° F. in 30 minutes. Removing the husk did not significantly increase cooling rate. Dessication was apparent around the edges and on the tips of the husk. Trimming and removal of outer layers restored fresh appearance. Browning, indicating frost or freeze injury, was found around the base of the ear.

Publications - USDA and Cooperative Program

Citrus Fruits

- Gaffney, J. J. and Jahn, O. L. 1967. Photoelectric color sorting of early season Florida oranges before degreening. Paper, Florida State Horticultural Society, Miami Beach, Fla. Also published in Florida State Horticultural Society Proceedings, Vol. 80, and in The Citrus Industry, Vol. 49, No. 2.
- Jahn, O. L., Yost, G. E., and Soule, E. J. 1967. Degreening response of color-sorted Florida oranges. ARS 51-14.
- Bowman, E. K. 1967. Paper, Prospects for automation in citrus packinghouses. Packinghouse Day, Citrus Experiment Station, Lake Alfred, Fla.
- Bowman, E. K. 1967. Citrus packing methods improvement. Citrus Industry.
- Bowman, E. K. 1968. Pushbutton packinghouse getting closer. Citrus World.
- Bowman, E. K. 1967. Guidelines for amount of investment for equipment changes. Packinghouse Newsletter, No. 12, Citrus Station Mimeo Report, CES 68-16.
- Bowman, E. K. 1967. Proper maintenance program for lift truck equipment vital to cost control. What's New In Agricultural Engineering, Agricultural Extension Service, University of Florida.
- Bowman, E. K. 1967. Handling citrus fruit in Florida. Paper, Meeting University of Florida Student Chapter AIIE.

Deciduous Fruit and Tree Nuts

- Burt, S. W. 1967. A brush sizer and sorter for apples. Proceedings, 63rd Annual Meeting, Washington State Horticultural Association.

- Burt, S. W. 1968. Love your apples? then give'm the 'brush off'.
American Fruit Grower.
1967. Grades, sizes produce with brushes. Food Engineering.
1967. Fruit graders not yet used in the Republic of South Africa. The
Deciduous Fruit Grower.
- Dewey, D. H. 1967. The MSU hydrohandling system for sizing and sorting
apples for storage in bulk boxes. Paper, Meeting of Maine Pomological
Society, Lewiston, Maine.
- Patchen, G. O. and Schomer, H. A. 1967. Hydrocooling apples for storage.
Proceedings, 63rd Annual Meeting, Washington State Horticultural Assoc.,
pp. 186-187.
- Patchen, G. O. and Schomer, H. A. 1968. Refrigerated storages and the
cooling of apples. Paper, New England Fruit Meeting, Concord, N. H.
- Schomer, H. A. and Patchen, G. O. 1968. Effects of hydrocooling on the
dessert quality and storage life of apples in the pacific northwest.
ARS 51-24, 6 pp.
- Patchen, G. O. 1967. Refrigerated storages. Paper, Western Regional Plan
Exchange Committee Conference, Oregon State University, Corvallis, Oregon.

Potatoes

- Wilson, J. B. and Hunter, J. H. 1967. Storage of fall flumed potatoes.
Paper, 17th Annual National Potato Utilization Conference, Presque Isle,
Maine.
- Herrick, J. F., Jr. 1968. A low-cost potato handling method. Business
Farming (N. J. Edition) Vol. 39, No. 5.
- Herrick, J. F., Jr. 1968. Potato handling trends in the packinghouse.
Business Farming (N. J. Edition) Vol. 39, No. 5.
- Herrick, J. F., Jr. 1968. Fluming fresh and stored potatoes and trends in
packing. Paper, Annual Meeting New Jersey Potato Association, Trenton,
New Jersey.
- Willson, G. B. 1968. Lateral pressures on walls of potato storage bins.
ARS 52-32, 15 pp.
- Yaeger, E. C. and Willson, G. B. 1967. Design and specifications for a
60,000 cwt. cross alley potato storage. Federal Cooperative Extension
Plan No. 6018. Plans 10 plates, specifications 15 pp.
1968. Potato storage--60,000 cwt. cross alley. Misc. Pub. No. 1069.
- Schaper, L. A. 1968. General engineering work concerning storage and
handling at storages--potatoes. Paper, Seminar Old Dutch Foods, Inc.,
Grand Forks, N. D.
- Schaper, L. A. 1967. Transportation and facilities research division
program at research center. Paper, Chipper Days, Grand Forks, N. D.
- Schaper, L. A. 1967. Opportunities for agricultural engineers and engineer-
ing technicians with USDA. Talk, Senior and Freshman Agricultural
Engineering Classes, North Dakota State University, Fargo, N. D.
- Yaeger, E. C. 1968. Problems in potato storage construction. Paper,
Central Aroostook Young Farmers' Association Seminar, Presque Isle, Maine.

Vegetables

- Stout, B. A., Ries, S. K., Bakker-Arkema, F. W., and Herrick, J. F., Jr.
1968. Handling tomatoes in pallet boxes. Marketing Research Report
No. 802, 14 pp.
- Veal, C. D. 1966. Some physical properties as they affect mechanical
removal of petioles. Master's Thesis, University of Florida.

AREA 5

LIVESTOCK, MEAT AND WOOL - MARKETING FACILITIES, EQUIPMENT AND METHODS

(RPA 505 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING LIVESTOCK)

USDA and Cooperative Program

Location of Intramural Work		Scientist Man-years FY 1968
<u>Livestock</u>		
	Missouri	1.2
<u>Meat</u>		
	Oklahoma	2.5
Total		3.7

Intramural program is supplemented by extramural support representing (a) 1.2 SMY's at State Agricultural Experiment Stations, and (b) 0.5 SMY's at other U.S. institutions.

Problems and Objectives

In 1966 the 52 terminal stockyards and 1,700 livestock auction markets handled over 50 million cattle, 75 million hogs and 15 million sheep. More than 50 billion pounds of meat was handled in about 20,000 plants. The livestock and meat marketing costs are estimated at \$10 billion. Much of this huge animal and animal product industry is operating in obsolete facilities using costly manual methods. Improved work methods, techniques, devices, operating procedures, equipment--including automated systems--and facility layouts are needed for receiving, handling, selling and shipping livestock and for slaughtering livestock and handling, fabricating, processing, storing and shipping meat and animal byproducts. Application of the results of these engineering research techniques could reduce marketing costs as much as \$50 million per year.

Major objectives of the research are to:

1. Minimize facility cost and increase productivity by developing efficient layouts for livestock markets and meat plants.
2. Reduce marketing costs by developing improved operating procedures and more efficient utilization of labor.
3. Reduce marketing costs by designing, constructing, and testing new or improved equipment that will replace expensive manual methods.
4. Minimize operating costs by developing techniques for adapting automated procedures to livestock and meat marketing.

Progress - USDA and Cooperative Programs

A. Livestock

1. Automating the Processing of Sales Data on Livestock Markets. A computer system for processing sales and accounting data on livestock auction markets was tested under a research cooperative agreement with the Computer Research Center, University of Missouri, Columbia, Missouri. The system, installed on the Central Missouri Auction Market, Mexico, Missouri, uses an IBM 1130 computer, a card reader and a list printer. All information is fed into the computer from punched cards. A seller's invoice and check are prepared automatically whenever the total number of livestock sold under his account number equals the number checked in. Deductions are made for meat board, inspection, charges for veterinary service, trucking and feed. Buyer's invoices provide data on weight and price and include charges, where applicable, for feed, trucking and commission. At the close of the sale a summary matrix is printed which tabulates the dollar volume for buyers and sellers under each species of livestock sold, tabulates dollar volume for each charge made and commission collected, and provides a listing of all checks written. The computer is also used by the market for processing payroll and other market records. A new cooperative agreement which

provides for converting the machine language of the present computer system into a common business oriented language, such as COBOL, was negotiated near the end of the report year.

2. Automation of Sales Operations on Livestock Markets. In cooperation with the Missouri Agricultural Experiment Station, at Columbia, a report providing construction details, drawings, and other information on the prototype electrically operated pen gates was completed and published during the report year. This completes the research scheduled under this project.

3. Layouts and Operating Criteria for Livestock Auction Markets. In cooperation with the Missouri Agricultural Experiment Station, at Columbia, field data were collected on market layouts, flow patterns, handling methods, weighing and selling practices, volume handled, and labor requirements on livestock auction markets in the Midwest, Southern and Northern Great Plains, and Southwestern areas of the United States. Livestock flow patterns for different market layouts were analyzed. An outline of a report updating existing branch publications on livestock markets was prepared. Work was underway on a draft of the publication at the end of the report year. The report will include a section or sections dealing with new developments in facilities and equipment for livestock markets.

B. Meat

1. Layouts and Work Methods for Hotel and Restaurant Meat Supply Houses. At Stillwater, Okla.; in cooperation with the Oklahoma Agricultural Experiment Station, the manuscript covering research in hotel and restaurant meat supply houses that prepare, package, and freeze the meat products and deliver orders from inventory was revised to include data on recently introduced meat fabrication equipment. The manuscript was resubmitted in January 1968. The report presents guidelines for houses that handle from about one to five million pounds annually and covers all major operations from receiving to loading out. Cost data were developed for an average size house, 3,500,000 pounds annually, which indicated that the use of the suggested methods and equipment could reduce operating costs by 9.5 percent.

2. Layouts and Work Methods for Beef and Veal Boning Lines. In cooperation with the Oklahoma Agricultural Experiment Station, Stillwater, a manuscript covering evaluation of bone handling procedures for beef boning lines was completed and published during the report year. Research to develop more efficient work methods, equipment, and layouts for beef and veal boning lines was continued. During the year experiments were started to determine the feasibility of boning beef carcasses on-the-rail. To date 47 carcasses have been boned on-the-rail and a tentative layout has been made for a boning line that would handle about 150 head daily. An analysis of the preliminary data indicates that an on-the-rail line would need less floor space than a separate table line and about the same space as a conveyORIZED

table line. Also it would eliminate sawing into primal cuts, reduce worker fatigue due to lifting and carrying heavy meat cuts, and may require less time to bone a carcass as workers develop skill in using the on-the-rail system.

3. Layouts and Work Methods for Small Inedible Rendering Plants. At Stillwater, Okla., in cooperation with the Oklahoma Agricultural Experiment Station, work was continued on layouts, equipment, work methods and operating procedures in small inedible rendering plants.

Cooperative work with the Animal Health Division also was continued during the year. Seven rendering plants of the continuous type were visited in Nebraska, Missouri, Arizona, Texas, and New Mexico, and several renderers of the batch type system were visited in Texas and Oklahoma. Case studies were made of each plant visited. Major conclusions from an analysis of case study data included a determination that the use of continuous rendering systems does not necessarily solve the sanitation problem in a rendering plant. Grinding operations, hogs or hoggers, hashers, and conveyors need redesigning to cut down on aerosols and sprays during operation. Most raw material conveyors were found to be open-top, and many times passed directly over conveyors moving finished product. Clean-out sections of conveyors need to be provided with hinged doors in most plants. Few renderers were found following the principle of raw material and finished material separation. An article entitled "Inedible Rendering Operations" was prepared and submitted to the Animal Health Division for presentation in their monthly division publication. The article provides drawings and descriptions of the four major continuous rendering systems in use in the United States.

4. Handling and Processing "Hot" Pork Carcasses. At Lincoln, Nebr., in cooperation with the Nebraska Agricultural Experiment Station, design drawings and specifications for the continuous flow chill cabinet were completed and were used to negotiate a procurement contract for the construction and installation of the cabinet. The contractor, Pennington and Son, Inc., Springfield, Illinois, constructed the cabinet and was assembling it in the University of Nebraska Meat Laboratory at the end of the report year.

Basically the chill cabinet is an insulated cabinet having two independently powered monorail systems transporting carts into, through, and from the cabinet. Pork cuts are transported through the system on cooling carts that can be used with shelves, with hanging products or with special cooling molds.

The chilling unit is designed to cool commercial cuts at the rate of 10 hogs per hour. The cooling temperature is -50° F. with airflow of 30,000 cubic feet per minute. Most cuts will be chilled in about 2 hours.

A three-dimensional scale model of the chill cabinet was constructed during the year.

Extensive effort has been devoted to the development of suitable molds for hams and loins. Several materials and designs were tested before an acceptable prototype was developed. An adequate number of ham and loin molds are being constructed to carry out the tests and experiments planned for subsequent phases of this research.

A light cabinet was constructed for the color stability evaluation phases of the project. Samples from hams of 94 hogs which were a part of another research project were made available, thus, substantial data have been collected. Laboratory analysis and evaluation of these results were in progress at year's end.

Experiments were started during the final quarter of the fiscal year to determine the effect of accelerated pork processing on sausage emulsions and their stability. Frankfurters and lard are being evaluated to determine shelf life and other properties related to the acceptability of "hot" processing of these products.

This research will benefit directly from new meat processing machines donated to the University of Nebraska by equipment manufacturing companies. The equipment, valued at approximately \$12,000, consists of two types of skinning machines, a "Comcure" pumping machine and an emulsion mill. The skinning and pumping machines will be incorporated in the pilot processing line.

5. Methods, Equipment and Facilities for Specialty Meat Plants. At Stillwater, Okla., research on economies of size in nonslaughtering meat processing plants was completed and a Technical Bulletin was published by the Oklahoma Agricultural Experiment Station. The publication provides data on the investment and operating cost requirements for three sizes of non-slaughtering meat processing plants designed to produce and handle meat products and customer service items in a ratio of 38.5 percent sausages, 38.5 percent cured meats, 15.5 percent fresh cuts, and 7.5 percent customer service items at three alternative percentages of designed capacity. Results indicated that a plant designed to produce 50,000 pounds per week would require an investment of \$451,221 in land, buildings, and equipment. One producing 100,000 pounds per week would require \$772,278 and a large plant producing 250,000 pounds, \$1,260,590. Data is provided on equipment, product flow, work area arrangement, and space requirement for the various components of the plant. The average processing cost per pound decreased from 11.29 cents per pound to 8.96 cents per pound as the plant size increased from 50,000 pounds per week to 250,000 pounds per week.

Publications - USDA and Cooperative Program

Livestock

McKibben, J. S., Obermeyer, J. H., and Mayes, H. F. 1967. Electrically operated automatic livestock gate. Missouri Agricultural Experiment Station Bulletin B863.

Meat

Schnake, L. D., Franzmann, J. R., and Hammons, D. R. 1968. Economies of size in non-slaughtering meat processing plants. Oklahoma Agricultural Experiment Station Technical Bulletin T-125.

Brasington, C. F., Hammons, D. R., and Webb, T. F. 1968. Procedures for handling byproducts removed during beef boning. ARS 52-29.

Mandigo, R. W. 1967. How soon accelerated pork processing? Meat Magazine.

Mandigo, R. W. and Henderson, R. L. 1967. Influence of hot processing techniques on various bacon parameters. Food Technology 21:98.

Mandigo, R. W. 1967. Accelerated pork processing. Cirascope-1968 Buyer's Guide. Chicago and Illinois Restaurant Association.

Mandigo, R. W. 1968. High temperature pork processing--cutting, fabricating, handling and yields. Proceedings of the Meat Industry Research Conference.

Mandigo, R. W. 1968. Hot cutting and processing of pork. Proceedings of the 20th Reciprocal Meat Conference. American Meat Sci. Association.

AREA 6

POULTRY AND EGGS - MARKETING FACILITIES, EQUIPMENT AND METHODS

(RPA 505 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING LIVESTOCK)

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years FY 1968
<u>Eggs and Egg Products</u>	
California	0.8
<u>Poultry and Poultry Products</u>	
California	0.7
Georgia	1.5
Total	3.0

Intramural program is supplemented by extramural support representing (a) 0.7 SMY's at State Agricultural Experiment Stations, and (b) 1.1 SMY's at other U.S. institutions.

Problems and Objectives

Processing poultry meat items, has become a highly complex food manufacturing process. Similarly, the processing, grading and packing of fine quality eggs and egg products has required drastic changes in the facilities, equipment and work methods. It is estimated that preparing these commodities for market costs the industry approximately 1.5 billion dollars annually. Little has been accomplished by industry in developing guidelines for new plants or in solving plant production problems involving the integration of new processes with large scale operations that frequently continue to use outmoded methods, facilities and equipment contributing to the high cost. By using guidelines for improving facilities, equipment and work methods, being developed by the Department through application of engineering research techniques it is estimated that the poultry industry will be able to reduce the processing costs one-half of one percent or approximately 75 million dollars annually.

Major objectives of this area of Department research are to:

1. Reduce construction cost and increase plant capacity by developing basic guidelines for efficient plant layouts and structural designs for poultry processing and egg grading and packing plants.
2. Decrease processing costs by more efficient labor utilization through an engineering analysis of work methods and development of improvements to implement new or existing processing facilities and equipment.
3. Fully utilize technological advances in food processing by designing, constructing, and testing of new or improved equipment that will reduce marketing costs while minimizing hazards to product quality.

Progress - USDA and Cooperative Programs

A. Eggs and Egg Products

1. Engineering Designs for Egg Grading and Packing Plants. In cooperation with the California Agricultural Experiment Station at Davis, a number of commercial plants within the desired size range were studied to evaluate the problem areas and to provide a basis for designing improvements. Building specifications, layouts, and functional area space requirements were determined to furnish guidelines for setting up design criteria.

Materials handling, materials storage, processing areas and product storage were considered in terms of overall arrangement, interrelationship, expansion potential, and structural design requirements. Procedures for calculating initial and changing space requirements, and techniques for planning functional work and storage areas were developed for a wide range of operating conditions. Structural design specifications were developed and engineering drawings have been prepared for the typical plant in this

volume range. The manuscript of a research report "Shell Egg Processing Plant Design" was completed and is now in the process of editing prior to publication.

2. Pasteurization of Liquid Whole Eggs for Small Volume Operations. This research carried out in cooperation with the California Agricultural Experiment Station at Davis, was completed and the results reported in two papers: (1) Batch Pasteurization of Liquid Whole Egg - Bacteriological and Functional Property Evaluation; (2) Batch Pasteurization of Liquid Whole Egg - Equipment Design and Operation; accepted and published in the Journal of Poultry Science, May, 1968. The results showed that holding whole egg at 135° F. for nine minutes is lethal to Salmonella, without significant damage to the functional properties of the product.

3. Egg Breakage Reduction in Commercial Egg Grading and Packing Plants. This research undertaken in cooperation with the California Agricultural Experiment Station at Davis, involves studies to determine the stress factors to which the egg shell is exposed to during processing operations. The beta backscatter method of measuring egg shell strength was investigated. Extremes of shell strength by impact could be predicted by this method. However, with shells of similar strength the effect of temperature on fatigue strength predictions were inconsistent.

In order to investigate the effect of thermal stress and external forces on egg shells, a stress analysis computer program was prepared. The elastic constants of egg shells, modulus elasticity, (6.8×10^{-6} psi), were determined. The thermal coefficient of expansion of egg shell was found to be 2.425×10^{-6} inch per inch of shell per one °F. The results of a check (cracked egg) survey of three processing plants showed a range of 4.9 percent to 6.8 percent checked eggs occurring during handling.

B. Poultry and Poultry Products

1. Weighing and Packing Turkeys. The results of this research, carried out in cooperation with the California Agricultural Experiment Station, Davis, was completed and the results were published in ARS 52-24 "Improved Equipment for Weighing and Packing Turkeys." The design detail for a semi-mechanized turkey packing line is presented. Operating tests of the equipment showed a labor saving of 15 percent over conventional equipment and methods for weighing and packing turkeys.

2. Mechanizing the Turkey Deboning Operation. In cooperation with the California Agricultural Experiment Station at Davis, an analysis of the current manual turkey deboning methods equipment was initiated and under contract with Gordon Johnson Co., Kansas City, Mo., the development of mechanized equipment, and related work methods for decreasing labor inputs and increasing the yield of prime meat cuts was started.

Methods-time measurement (MTM) studies of conventional turkey deboning operations were carried out in a test plant and development of a power driven cutting tool for improving deboning operations was continued.

Practical sampling and test methods to determine the exact weight of prime meat cuts and scrap meat yield from individual birds deboned in the conventional manner were perfected. Bacteriological studies of the equipment, workers and product, considered critical to product quality were carried out.

An experimental mechanized turkey deboning line, employing an innovated rigid shackle, a suspension device, and an automatic bird positioner was designed, constructed and successfully tested in the contractor's laboratory. Application for public patent on the shackle innovation has been registered.

3. Eviscerating Turkeys in Commercial Processing Plants. This research carried out in cooperation with the California Agricultural Experiment Station, Davis, was initiated during the year. The work will be carried out in commercial plants for the purpose of improving the efficiency in eviscerating operations.

The eviscerating methods, equipment and techniques employed by a typical turkey processing plant were studied. The results will serve as criteria in evaluating other turkey plants as possible case study sites for conducting this research. Methods Time Measurement (MTM) and motion picture techniques were employed to establish motion patterns for eviscerating methods. Nine West Coast plants were selected as suitable case study sites. Management and Department inspection personnel in these plants were interviewed for their approval and cooperation in plant studies.

4. Cutting Up and Packing Chickens - This research conducted in cooperation with the University of Georgia Agricultural Experiment Stations at Athens, involves studies to develop and test new or improved methods and equipment for cutting up chickens. Two cut-up system components were constructed and tested.

One is a machine that removes the vertebra and splits the breast portion of the carcass at a rate of about 30 per minute. The vertebra is removed and the breast split at a rate of about 40 per minute. Another feature allows the carcass to be split in half without removing the vertebra. These two features of the machine result in mechanizing about one-half of the cuts required for processing the standard parts of the chicken carcass. Its full-time use would reduce the overall cutting room labor costs by approximately one-third.

The other component is a portable monorail conveyor for use in small cut-up operations. It is quickly and easily assembled or disassembled, mounted on floor-supported posts, and has a self-contained motor and drive. Its

especially designed rigid shackles allow mechanical unloading of parts (legs or wings) after the remainder of the carcass has been cut away.

5. Designs and Layouts for Chicken Processing Plants. This research was conducted in cooperation with the University of Georgia Experiment Stations at Athens. Results, now in manuscript form, "Guidelines for Poultry Processing Plant Layouts" sets forth good layout practices for each area of the processing plant and illustrates and discusses how these areas are built into a compact efficient plant. A typical plant layout is developed for 4,800 birds per hour with design features that permit expansion to double the capacity without requiring a shut down and at minimum cost.

6. Handling Live Chickens by Commercial Processing Plants. This research is being carried out in the Southeast in cooperation with the University of Georgia Agricultural Experiment Stations at Athens, to develop improved methods and equipment for reducing labor requirements and bruise damage to live chickens. Data from studies in North Carolina, Virginia, and Georgia, confirmed findings that at least 50 percent of downgrading bruises occur within the broiler house prior to catching and cooping operations.

Data collected from over 50 grower houses, involving 8 - 10 growout cycles per house and over 2-1/2 million chickens, were programmed for correlating housing conditions and other factors to downgrading bruises.

In cooperation with the USDA Grading Service and the North Carolina State Department of Agriculture, 25,000 chicken carcasses from 250 flocks were examined for bruise damage sufficient to downgrade the carcass. The average for all flocks was 18.7 percent downgrades.

A study of bruise incidence as related to the growout facilities and management practices was undertaken in a Georgia Experiment Station broiler house which was modified to test the effectiveness of blue light during caretaker activity in reducing the incidence of bruises. Blue lights (instead of usual white lighting) were turned on during caretaking operations so that flock activity remained low. Concurrently, similar testing with blue lighting was undertaken in three commercial broiler houses. Bruise data was obtained on flocks from the houses prior to the time that changes were made for comparison against test data. Bruise samples from the first flocks raised in the modified lighting (blue only during caretaker activity) houses showed only 63 percent as many bruised chickens as under standard (white) lighting.

Studies of problems involving processing plant live chicken handling crews included: (1) Evaluation of current methods of catching, cooping, and loading chickens, (2) laboratory tests of a mechanical conveyor system for loading and cooping chickens, and (3) constructing models for two mechanical devices for unloading chickens at processing plants; one device for small volume plants (up to 3,600 birds per hour) and the other for plants operating above this volume.

7. Reducing Water Use Rates in Poultry Processing Plants. This research was initiated at Athens, in cooperation with the University of Georgia Agricultural Experiment Stations.

A literature search was conducted and poultry plant managers and city water works administrators were questioned concerning water utilization. Representatives of companies selling and distributing water measuring and metering devices were consulted regarding the equipment and instrumentation needs for this research. A list of case study plants representing typical variables affecting water use rates was developed.

8. Slaughtering and Defeathering Chickens in Commercial Plants. This long-term research was initiated at Athens, in cooperation with the University of Georgia Agricultural Experiment Stations, during the latter half of the report year.

A literature search and review was initiated and observations were made of current slaughtering methods and equipment.

Publications - USDA and Cooperative Program

Eggs and Egg Products

Brant, A. W., Patterson, G. W., Walters, R. E., Waul, Cheryl. 1967.

Further Developments in Batch Pasteurization of Liquid Whole Egg. A technical paper presented at the 56th Annual Meeting of the Poultry Science Association, New Hampshire.

Brant, A. W., Patterson, G. W., Walters, R. E. 1968. Batch Pasteurization of Liquid Whole Egg I - Bacterial and Functional Property Evaluation. Poultry Science Journal.

Walters, R. E., Brant, A. W., Patterson, G. W. 1968. Batch Pasteurization of Liquid Whole Egg II - Equipment Design Aspects. Poultry Science Journal.

Poultry and Poultry Products

Walters, R. E. 1968. Improved Equipment for Weighing and Packing Turkeys. ARS 52-24.

Childs, Rex E. 1967. The problems of downgrading bruises. A technical paper presented at a meeting of the North Carolina Poultry Processors' Meeting.

Childs, Rex E. 1968. Relationship of handling techniques and growout environment to downgrade bruises of live broilers. A technical paper presented at a meeting of American Society of Agricultural Engineers, Louisville, Ky.

Childs, Rex E. 1968. Bruising research relating to growing and handling broilers. A technical paper presented at the annual Georgia Broiler Seminar, Gainesville, Georgia.

Childs, R. E. 1968. Efficiency in Poultry Eviscerating and Inspection Operations. Marketing Research Report No. 813.

Hamann, J. A. 1968. USDA Research into New Equipment and Processing Methods. Paper presented at the Annual Quality Control School, Chicago, Ill.

AREA NO. 7

CONSUMER PACKAGES AND SHIPPING CONTAINERS

USDA and Cooperative Program

Location of Intramural Work	: Scientist Man Years F. Y. 1968				
	: Research Problem Area :				
	: 503	: 505	: 601	: 906	: Total
<u>Fruits and Vegetables</u>	:	:	:	:	:
Maryland (Hyattsville)	: 2.7	:	: 1.0	:	: 3.7
California	: 1.0	:	: 0.1	:	: 1.1
Florida	: 0.9	:	: 0.1	:	: 1.0
Washington	: 1.2	:	: 0.8	:	: 2.0
Total F & V	: 5.8	:	: 2.0	:	: 7.8
<u>Animal Products</u>	:	:	:	:	:
Maryland (Hyattsville)	:	: 0.5	: 0.4	:	: 0.9
<u>Floral Products</u>	:	:	:	:	:
California	:	:	:	: 0.9	: 0.9
Total	: 5.8	: 0.5	: 2.4	: 0.9	: 9.6

Intramural program is supplemented by extramural support representing (a) .3 SMY's at State Agricultural Experiment Stations, and (b) .9 SMY's at other U. S. institutions.

Problems and Objectives

Shipping containers and other packaging are indispensable for efficient movement of farm products from widely dispersed areas of production through our complex marketing system to industrial concerns engaged in further manufacturing and to ultimate consumers located throughout the world. It costs about \$10 billion a year to package food products. The American marketing system is characterized by dynamic innovation processes constantly striving to increase efficiency and utility. New and improved packaging is necessary to facilitate desirable changes in transport and handling equipment and techniques, consumer preferences and market organization. New packaging concepts also stimulate improvement in other parts of the marketing system.

This is a continuing program of applied research conducted by marketing specialists, industrial engineers, and agricultural economists. Current research is on deciduous fruits, citrus fruits, vegetables, cut flowers, and poultry products. The program is carried on in cooperation with experiment stations and industry in main producing areas and in the principal domestic and overseas terminal markets. Major objectives of this research are to:

- (1) Develop modular size containers and performance criteria.
- (2) Reduce costs of marketing.
- (3) Protect consumer health by sanitary packaging.
- (4) Provide more services and conveniences to consumers.
- (5) Reduce spoilage and nutritional losses.
- (6) Help maintain and strengthen the competitive position of U. S. exports.
- (7) Help develop new foreign markets.
- (8) Increase the income of producers.

Progress-USDA and Cooperative Programs

RPA 503--PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING FRUITS AND VEGETABLES

1. Apples. Laboratory tests and three rail test shipments of molded-pulp deep-cup trays trimmed to fit the same box used for conventional molded-pulp shallow-cup trays indicate that containers with trimmed deep-cup trays protected Golden Delicious apples about as well as containers with untrimmed deep-pocket trays but packaging material costs were reduced by 2 cents per box. The pack using trimmed deep-pocket trays cost 11 cents per box less

than corrugated cell-pack containers. The 1968 test data are being incorporated in a report on research done in previous years evaluating cell-pack and tray-pack containers for Golden Delicious apples.

2. Apricots. Jumble-packing apricots in fiberboard boxes and shipping them costs 1.5 cents less per pound than for marketing them place-packed in wood boxes. Damage from bruising was 33 percent in jumble-packed boxes and 36 percent in place-packed boxes. The potential annual savings in packaging and transport costs for all fresh apricots shipped from California, Washington, and Utah in jumble-packed fiberboard boxes would be about \$530,000 per year. A manuscript, "Jumble Packing Fresh Northwest Apricots and Prunes: Comparative Cost and Performance of Wood Boxes, Wood-Veneer Baskets and Fiberboard Boxes," has been prepared.

3. Italian Prunes. Jumble-packing Italian prunes in fiberboard boxes and shipping them costs 1.8 cents less per pound than marketing them face-packed in wood-veneer baskets. Damage from bruising was only 7 percent in the new boxes as compared to 21 percent when prunes were shipped in the wood-veneer baskets. The potential annual savings in packaging transport costs for fresh prunes shipped from Idaho, Washington, and Oregon in jumble-packed fiberboard boxes would be about \$953,000 per year. A manuscript, "Jumble Packing Fresh Northwest Apricots and Prunes: Comparative Cost and Performance of Wood Boxes, Wood-Veneer Baskets and Fiberboard Boxes," has been prepared.

4. Table Grapes. California grapes packed in expanded polystyrene foam shipping containers arrived in Eastern markets with fewer bruised and shattered berries than grapes packed in standard wood display lugs. These results were obtained from test shipments made during the 1966 and 1967 grape seasons. Net savings obtained from packing and shipping grapes in polystyrene boxes were estimated to be 4 to 6.2 cents per box of 26.5 pounds of grapes. Receivers generally liked the polystyrene foam boxes for grapes, although breakage of the boxes was a problem in test shipments. Preliminary tests in which the foam boxes were palletized for shipment as a means of preventing excessive box breakage were partially successful.

5. Temple Oranges. Investigations on Temple oranges packed in plastic cell trays, and place-packed in fiberboard boxes and wirebound crates, have been completed. Sixteen truck test shipments were made from Florida to five Eastern terminal markets. Temple oranges packed and shipped in polyvinyl chloride (PVC) cell trays arrived in terminal markets with less bruising than comparable oranges place-packed in wirebound wood crates or fiberboard boxes. The cost of packing, handling, and shipping (1,000 miles) Temple oranges in the PVC cell trays and fiberboard boxes was \$1.91 per 4/5 bushel box equivalent, \$.94 for wirebound crates and \$.85 for fiberboard boxes.

6. Citrus. Minimum performance standards and container criteria for rating and evaluating Florida orange and grapefruit boxes are being developed in cooperation with the Florida Citrus Commission. The performance standards and container criteria will be used by the Commission to improve the

performance of citrus boxes and to evaluate proposals for new containers. New containers that meet or exceed the performance standards will be considered for further testing and evaluation under commercial conditions.

7. Grapefruit and Murcott Oranges. Exploratory studies of the marketing of ready-to-serve grapefruit halves and peeled whole Murcott oranges were continued. Potential market outlets were explored and chainstore and institutional buyers encouraged continuation of the work.

8. Plums, Nectarines and Bartlett Pears. Investigations to determine the costs and feasibility of marketing Western plums, nectarines, and Bartlett pears packed in three sizes of shipping containers and prepackaging them in terminal prepackaging plants and retail stores were completed by the contractor, Food Industries Research and Engineering. The fruit was packed in place-packed boxes, jumble-packed boxes and large bulk-bin boxes and shipped to Cleveland, Ohio, or Boston, Massachusetts, where it was prepackaged and sold. The final report submitted by the contractor summarizes the work done, presents detailed cost analyses of packaging, handling, transport, and retailing these fruits and draws conclusions from the data obtained. Terminal market prepackaging firms and retail stores can reduce their costs of prepackaging plums and pears by buying them in jumble-pack boxes or large bulk-bin boxes. Because of higher spoilage loss in the jumble-packed boxes terminal market prepackaging plants and retail stores can reduce the costs of prepackaging nectarines by buying them in large bulk-bin boxes.

9. Tomato Transplants. In cooperation with Crops Research Division, ARS, the feasibility of developing improved containers for shipping tomato transplants from Georgia to northern tomato producing areas was investigated. Tomato transplants are usually harvested and then graded and packed in bunches wrapped with peat moss and Kraft paper in packing sheds. Less labor and materials are used for packing bunches of tomato plants with bare roots rather than wrapping them with peat moss and Kraft paper. Four truck test shipments of tomato transplants, bare roots and roots wrapped with paper packed in conventional wirebound crates and experimental fiberboard boxes, with and without polyethylene liners, were made from Georgia to New Jersey. Bare root plants packed without box liners were acceptable upon arrival at destination. Leaves of bare root plants in fiberboard boxes with polyethylene liners turned yellow. Plant survival tests at Beltsville resulted in no statistically significant difference in field survival between treatments planted without delay. When plants were stored four or ten days prior to shipment, field survival of bare root plants in wirebound crates and fiberboard boxes without box liners was higher than plants with paper wrapped roots in wirebound crates and bare root plants in fiberboard boxes with polyethylene liners.

10. Standardization of containers for fresh fruits and vegetables. A pilot study on the extent of use, dimensions, net weights and specifications of shipping containers used for fresh fruits and vegetables in the United States was completed under contract by the Research Triangle Institute, Raleigh,

North Carolina. The pilot survey was undertaken in four warehouses, in each of the cities of Los Angeles and New York over four seasons of the year. In the pilot study 44 different size boxes were found in use for apples, 8 for oranges, and 22 for cauliflower.

RPA 505--PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING
ANIMAL AND ANIMAL PRODUCTS

1. Poultry: The use of polystyrene foam boxes for the shipment of fresh dressed poultry was tested. Ten pounds less ice is used when poultry is ice-packed in polystyrene foam boxes instead of in wirebound wood crates and polystyrene boxes weigh four pounds less than the wirebound crates. The polystyrene box costs more than the wirebound box but savings in packing labor and package ice offset this higher cost. Significant savings in transport cost can be obtained because a packed polystyrene box weighs about 14 pounds less than a wirebound box packed with the same amount of poultry. Additional research is needed to increase the strength of the polystyrene boxes and to develop better ways of handling them during distribution. Preliminary investigations of the use of CO₂ snow instead of water ice as a refrigerant for fresh dressed poultry packed in fiberboard and polystyrene foam boxes indicate that significant savings in transport cost may be realized. Packed boxes with CO₂ snow weigh about 20 pounds less than packed boxes with water ice.

RPA 601--EXPANSION OF FOREIGN MARKETS FOR U. S.
FARM PRODUCTS

1. Fruits and Vegetables. Investigations to reduce the costs of marketing exported apples were continued. Thirteen test shipments of Golden Delicious, Red Delicious and Newton apples packed in experimental containers and shipped from the Northwest and Virginia to Europe have been completed. Preliminary data indicate that packing and handling apples in 800-pound, 4-cell pallet boxes instead of 42-pound boxes and handling 42-pound boxes palletized instead of individually offer significant savings. Trimming the edges of the molded-pulp deep-pocket tray did not reduce protection to the apples but did reduce container costs by 2 cents per 42-pound box. Packing Golden Delicious apples in trimmed deep-pocket tray pack instead of the conventional cell-boxes used for export reduces the costs of packaging materials by about 26 cents per hundred pounds.

Rutgers University completed a contract studying the feasibility of packing and shipping cell-pack Golden Delicious and McIntosh apples in 50 by 30 cm. boxes--one of the proposed European standard containers. The final report submitted by the contractor presents detailed cost analysis of packaging materials, handling and packing labor costs, transport charges, condition of container and apples when the apples are packed in 50 by 30 cm. boxes and in control boxes (boxes currently used by U. S. apple shippers). McIntosh apples and Golden Delicious apples packed in cell boxes with 50 by 30 cm. outside dimensions did not show any more bruising than

comparable apples packed in conventionally used cell-pack boxes in test shipments made from apple producing areas to New York City. The tests indicate that the packing of all the sizes of apples of these two varieties that are exported in one dimensional size cell-box would increase the costs of placing apples in Europe about $\frac{1}{4}$ to $\frac{1}{2}$ cent per pound. A report for publication is being prepared.

Research to develop packaging that will provide better protection for celery shipped to overseas markets was continued. Container specifications and packing patterns were developed for prototype celery shipping containers manufactured from (1) expanded polystyrene foam, (2) wax-dipped fiberboard, and (3) curtain-coated (polyethylene wax) fiberboard boxes. Exploratory van container shipments from Florida to Germany showed that after 16-day average transit periods celery packed in polystyrene containers arrived in excellent condition, green and very crisp. Celery packed in wax-dipped fiberboard boxes arrived in comparable condition to celery packed in conventional wirebound crates. Two test shipments of celery packed in 2/3 size curtain-coated fiberboard and fiberboard-wood-frame boxes arrived in Puerto Rico and Landover, Maryland, with fewer bruised and broken ribs than celery packed in the conventional wirebound crate.

Development of more efficient containers for soft fruits and citrus for air and boat shipment to overseas markets were continued. Exploratory tests have shown that the use of expanded polystyrene foam boxes can reduce air transport charges. Prototype containers of expanded polystyrene foam and wood have been designed and obtained. The outside dimensions of these containers are 50 by 30 cm. which fully use the space on a 48- by 40-inch pallet or the European 120- by 100-cm. pallet. A fiberboard full-telescope container of this size is also being made. Laboratory analysis of the 50- by 30-cm. container indicates this container will hold about 20 pounds of peaches, plums, or nectarines. Additional research is being conducted to determine the container size and type of material best suited to specific fresh fruits and vegetables. Work to develop a citrus container that would efficiently fit a 48- by 40-inch pallet and would provide adequate ventilation to the fruit in ventilated van container shipments was begun at Orlando, Florida.

2. Poultry. Boxes constructed of 275-pound test corrugated fiberboard reinforced with two steel straps are commonly used for overseas shipment of frozen poultry. The use of boxes constructed of 200- and 250-pound test fiberboard and the necessity of steel-strapping boxes shipped to Europe in van containers was tested. The 200- and 250-pound test boxes and boxes with only one steel strap and without straps arrived in European markets in as good condition as 275-pound boxes with two steel straps. Savings in packaging material and strapping of 6.7 cents per box could be obtained by using the 200-pound test box without straps. However, buyers who feared pilferage during distribution from warehouse to retail stores, say they want one strap per box.

RPA 906--CULTURE AND PROTECTION OF ORNAMENTALS AND TURF

Colorado Carnations. The use of different types of box liners and accessory packaging materials for packing Colorado carnations in fiberboard boxes was tested. Polyethylene film laminated to crepe paper and an expanded polystyrene foam liner provided better insulation at less cost than currently used materials such as macerated paper blankets and air cell liner materials. The feasibility of increasing the density of flowers packed in fiberboard boxes and shipped by air is being tested. Packing and shipping 400 cut carnations instead of 200 cut carnations in a standard shipping container can save the Colorado flower industry \$110,000 per year.

Publications--USDA and Cooperative Program

Stokes, Donald R., and Mallison, Earl D., September 1967, "International Standardization of Packaging for Fruits and Vegetables," The Packer

Stokes, Donald R., "How Packaging Helps to Improve Produce Marketing," March 1968, Packaging Seminar for Agriculture, Michigan State University, East Lansing, Michigan.

Chapogas, Peter G., "Expanding Exports Through Better Physical Distribution," March 1968, International Conference on Handling Perishable Agricultural Commodities, Purdue University, Lafayette, Indiana.

Thompson, James E., Mercuri, Arthur J., and Risse, Lawrence A., April 1968, "Shipping Containers for Ice-Packed Poultry--Effect on Microbial Counts and Weights of Poultry and Ice," Marketing Research Report No. 811, U. S. Department of Agriculture.

Nicholas, C. J., and Risse, Lawrence A., July 1968, "Transporting Packaged Frozen Poultry to European Markets in Van Containers and Break-Bulk Shipments," An Interim Report, ARS 52-28.

AREA NO. 8

TRANSPORT EQUIPMENT AND TECHNIQUES

USDA and Cooperative Program

	Scientist Man-Years F.Y. 1968						
Location of Intramural Work:	Research Program Area						Total
	503	504	509	601	906		
<u>Equipment</u>							
Maryland (Hyattsville)		0.8	3.3		1.1	5.2	
Total Equipment		0.8	3.3		1.1	5.2	
<u>Techniques</u>							
Maryland (Hyattsville)	1.8		1.1	2.8		5.7	
Florida	0.8		0.1	1.1		2.0	
Total Techniques	2.6		1.2	3.9		7.7	
Total	2.6	0.8	4.5	3.9	1.1	12.9	

Intramural program is supplemental by extramural support representing (a) 0.3 SMY's at State Agricultural Experiment Station 1/, (b) 0.0 SMY's at other U.S. institutions, (c) P. L. 480 funds in 6 countries representing \$1,247.90 U.S. dollars equivalent 2/, and (d) 1.6 SMY's at industry firms through contracts 3/.

1/ RPA 509 0.3

2/ RPA 601

3/ RPA 503 0.8, RPA 509 0.8

Problem and Objectives. The cost of transporting U.S. farm products to domestic and overseas markets in 1967 was about 9.5 billion dollars. In addition, substantial product loss and damage occurred during transport because of inadequate temperature protection, poor loading and stowage methods, and excessive handling of the products. Economic-engineering research to develop and apply new transport and engineering technology to transporting agricultural products can lead to savings of about 1.4 billion dollars annually in marketing costs. This program will help increase returns to farmers, provide better products at lower costs to American consumers, and improve the competitive position of our products in foreign markets.

Major present objectives of the research are to lower costs and improve transport performance by:

1. Developing new refrigeration methods for vehicles used to transport perishable agricultural products.
2. Developing more versatile transport vehicles of lighter weight and higher capacity for grain, milk, and other bulk products.
3. Developing loading and stowage methods to increase cargo space utilization in transport vehicles and reduce damage to packaged products.
4. Reducing the number of handlings of products by means of van containers, palletization, and other unit load techniques.
5. Finding better ways to integrate the various modes of transport to obtain lower total transport and distribution costs.

Progress - USDA and Cooperative Program

Transport Equipment

RPA 504 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING FIELD CROPS

A. Grain Transport in Boxcars

A study of defects and losses in 1989 boxcar shipments of grain was completed during the year. Of the boxcars inspected, 55 percent were classified as defective and the remaining 45 percent had no defects. Differences between recorded origin and destination weights for corn and soybean cars were so varied that definite conclusions about the relation between losses and defects could not be drawn. Analysis of wheat car data showed that cars

with defective walls had a mean loss of 268 pounds more than cars without that defect. Cars with defective floors had a mean loss of 360 pounds more than cars without such defect. Cars with paper grain doors had a loss of 324 pounds more than cars with wooden doors. All of the differences were statistically significant.

The report on this work will be published as soon as it is cleared by the last USDA reviewing agency.

RPA 509 - MARKETING FIRM AND SYSTEM EFFICIENCY

A. Nitrogen Refrigeration for Trailers

The objective of this study is to compare the cost and performance of liquid nitrogen and mechanical refrigeration systems used in trailers hauling perishable products. Research was begun using two mechanically refrigerated and two nitrogen refrigerated trailers used in metropolitan area delivery of medium temperature foods. The vehicles were identical, except for type of refrigeration unit. Ten exploratory tests were made with trailers to develop instrumentation and procedures for obtaining temperatures of commodity, inside air, and outside air during delivery runs. Data sheets and procedures also were developed for recording fuel and maintenance costs for each vehicle.

A 12-month test program was started in which the four vehicles could be tested on a rotating basis at the rate of two trailer tests per week. At the close of the reporting period, 18 tests had been completed. In each test, air and product temperature, number and length of door openings, and total time that load is under refrigeration were recorded. A continuous record of fuel and maintenance costs for each vehicle also was made.

B. Refrigerated Truck Door Openings

A test program was developed and agreed upon between the National Bureau of Standards and the USDA in which the Bureau will conduct laboratory tests of two refrigerated trucks to determine refrigeration loads caused by door usage. Funds provided for this project in F.Y. 1968 were used principally for purchase of test equipment. The test program will begin during the next year.

C. Thermal Efficiency of Refrigerated Vehicles

A representative of the ARS participated in two meetings of the Working Party on the Transport of Perishable Foodstuffs of the Inland Transport Committee of the Economic Commission for Europe. At these meetings action has been taken to amend a 1962 agreement on testing and certifying of refrigerated and heat vehicles used in international transport of perishable foods. U.S. equipment used to ship perishables to Europe will be subject to provisions of the agreement.

Specifications were developed for a 12-month test program to study the effect of refrigerated truck door usage on cargo temperature and refrigeration load for light and heavy delivery schedules, for mechanical and eutectic plate refrigerated vehicles, and for three cargo products. Vehicles will be tested in an ambient of 100° F. and 50 percent relative humidity.

D. Multi-Purpose Van Container

The major objective of this research is to develop a multi-purpose van container having a number of new and improved features which will provide better protection for perishable products during transport and improve the versatility of the vans for more efficient, lower cost operation. Modifications and structural design work on a 40-foot prototype refrigerated van container were about 60 percent complete at the end of the reporting period. The refrigeration unit, primary power plant, fuel tanks, floors, and meat-rails were removed from a conventional 36-foot refrigerated trailer and the van was modified to meet the engineering specifications of the ARS concept. The completed work consisted of extending the trailer body to 40 feet, fabrication of a 40-foot detachable chassis, installation of a new floor, sidewall and ceiling air plenums, refrigeration coils, air blower assemblies and nose mounted refrigerated unit. A cube weight analysis, alternative refrigeration systems evaluation, and preparation of an outline for reporting the results in an interim report also were done during the year. Also completed was a comparison of the features of the concepturized design for the van, the prototype van and conventional refrigerated vans. Engineering work to develop designs for some planned modifications in the prototype van was done. Plans for transport testing of the prototype van in cooperation with shippers, railroads, truck lines and ocean carriers were prepared.

E. Trailer Conversion Systems

The predominant type of van trailer equipment in use today, for highway, trailer-on flat car, and other forms of containerized shipments, is used only for transport of packaged cargo. This type of trailer is not suitable for the transport of bulk cargo such as grain, potatoes and dry flowable products such as flour. The major objective of this research is to develop conversion systems for the vans so they can transport either dry or liquid products in bulk as well as packaged cargo. This change will improve the utilization rates of the van and reduce transport costs. This work is being done in cooperation with the Oregon Agricultural Experiment Station.

1. Dry bulk cargo. Work on revising a report for publication of the results of this research was done during the year. The report covers the development of conversion systems for conventional van trailers which enable them to transport dry bulk cargo. The conversion systems, which can be installed in vans already in service, increase the utilization of the equipment by making it possible for the truckers to carry payloads in both

directions. The systems also help reduce handling costs because they permit mechanical loading and unloading of the bulk products. With one of the conversion systems it is possible to transport granular products such as grain and pelletized feeds, and bulk shipments of apples and potatoes in refrigerated and non-refrigerated vans. Another system makes it possible to transport dry flowable products such as flour with the convenience of pneumatic loading and unloading.

2. Bulk liquid cargo. Large collapsible, rubber-coated fabric tanks with disposable plastic film liners were developed for transporting liquids in closed van trailers. A new method for bleeding the air trapped between the disposable film liner and the rubber tank during inflation while filling was developed to correct problems encountered in earlier tests. Additional tests were conducted on shipments of milk to determine use factors and obtain cost data for an analysis of utilization and revenue yields. The tanks are already being used by one chain store in the Pacific Northwest to transport 4,500 gallons of milk to its processing plants after delivering groceries to a number of supermarkets near milk producing areas. Other bulk cargoes being transported in the tanks are grape juice and liquid sugar. A report on the results of this research is being prepared by the Oregon Experiment Station.

F. Air Circulating and Humidifying Systems.

1. Reducing Fluctuation of Air Temperature in Refrigerated Trailers. Temperature of the air discharged onto the cargo in many conventional refrigerated trailers may vary from 20° to 60° F. in a matter of a few minutes, causing damage to products from alternate cooling and heating. Extreme temperature variations found in this study were caused by the cycling of the refrigeration units from high speed cooling to high speed heating. A performance test was made on a refrigerated load using a conventional refrigeration system controlled by a new four-stage Thermac-5 unit. The new system is designed to reduce fluctuation in the temperatures of the air discharged into the cargo area by cycling from low speed cool to low speed heat after the temperature of the circulating air has reached the thermostat setting. Preliminary results indicated that the new system may have some advantages over the conventional refrigeration system in reducing product damage resulting from extreme fluctuation in air temperatures during transport.

2. Humidification of Circulating Air. In shipments of some leafy vegetables by truck and rail piggyback up to 4,000 pounds of crushed ice is placed on top of the loads to provide the dual benefits of rapid cooling and needed moisture from the melted ice to retain freshness. But many top-iced shipments suffer high rates of loss and damage caused by the overhead weight of the ice, compared with shipments that are not top-iced. Five tests with a highway refrigerated trailer equipped with a humidifier to add moisture to the circulating air during transit were made during the year. Mechanical failures of the humidifying unit during some of the tests limited the value of most of the data developed. However, the work indicated that use of a

humidifier in conjunction with a mechanical refrigeration unit could eliminate the need for using top-ice on trailer shipments of certain vegetables. This should reduce savings in icing costs and container and product damage.

Transport Techniques

RPA 503 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING FRUITS AND VEGETABLES

A. Unitized and Palletized Loading and Transport

1. Citrus Fruit. More efficient, lower cost methods of handling and shipping citrus are needed to help offset rising costs in the citrus industry. The purpose of this research is to develop unitized and palletized loading techniques for fresh citrus that will reduce product damage and handling and shipping costs.

Stacking patterns for pallet-size handling units of citrus were developed for the 4/5-bushel box and the bagmaster box. The handling units were tested for stability and for adequacy of air circulation when loaded in a trailer. A fully loaded trailer contains 18 handling units. The pallet size used was 48 by 40 inches because this is the size most generally used by food distribution industry. It was found that handling units of the 4/5-bushel boxes and bagmaster boxes on pallets did not provide a large enough payload. A handling unit of 54 boxes of the 4/5-bushel size was developed for slipsheets that would provide a large enough payload.

Tests were made in an air circulation chamber to compare the cooling rates of boxed citrus using different types of containers, stacking arrangements and types of pallets. The cooling rates of the handling units arranged in the tight-stacked and air-flow patterns were compared. The results indicated that during the critical initial cool down period the air-stack pattern had a greater rate of cooling than conventional tight stack pattern during the first 18 hours. After 18 hours, the cooling rates were almost identical for the two patterns. Also, tests were made to compare cooling rates in the conventional 4/5-bushel box, air-flow pattern with air introduced into the load at the top front of the test chamber; and a 4/5-bushel box with grid pattern openings cut into the tops and bottoms and in a tight-stack pattern with air introduced into the load at the floor level. Test results indicated that the experimental box permitted air circulation throughout the load. But the grid pattern cut into the experimental boxes weakened them. The bottoms broke out of 4 percent of the boxes when handled after 48 hours under refrigeration.

Twelve highway trailers and one rail piggyback shipping tests were made with air-flow and tight-stacked handling units on disposable pallets and slipsheets. Some load shifting was observed at destination in three of the loads with the air-flow handling units, resulting in some blockage of air

channels. Product temperatures in loads arriving in this condition were from 5° to 8° F. higher in the center than around the periphery of the load. But the air-flow loads generally arrived in good condition with less temperature variation throughout the load than in the tight-stacked loads. Tight stacked shipments arrived in good condition with little or no load shifting. The disposable pallets proved unsatisfactory. The weight of the handling units combined with the motion of the trailer over the road caused some disposable pallets to collapse. Others had stringers which were not of sufficient height to permit entry of the forks on the electric transporters used for unloading. All the disposable pallets tested cost over \$1.00 each and were not considered economically feasible.

Labor and equipment data were obtained to compare costs of unitized shipments with those of the conventional hand stacking methods. Labor input data obtained for unitized shipments are not considered representative for unitized handling. Inexperienced personnel operating equipment for handling slipsheets required more time than was considered necessary for loading and unloading operations. Inexperienced in loading results in some of the tabs on the slipsheets becoming crimped so that they could not be gripped by the special attachment on the forklift without manual assistance.

The 4/5-bushel box is the predominant container used for shipping citrus. Both the corrugated and wirebound 4/5 bushel boxes are well suited for the stacking arrangements used to make up the handling units. A survey was conducted at 29 of the 35 larger citrus packinghouses in Central Florida to determine the type of plant facilities and equipment in current use. The results showed that the larger packinghouses had loaded platforms and space for stacking, handling and storing that would permit them use of a unitized loading system. The main deficiency was in the type of equipment used. Only half the houses surveyed had forklift trucks which could be adapted with attachments for handling pallets and only two had forktrucks equipped to handle slipsheets. But the type of equipment needed is available from the various equipment manufacturers.

2. Potatoes. A report covering the results of exploratory research to determine the feasibility of developing more efficient, lower cost methods of unitizing consumer size bags of potatoes was received from the contractor, Food Industries Research and Engineering, Inc., Yakima, Washington. The study sought to determine, from both the engineering and cost standpoints, the feasibility of unitizing, automatically and semi-automatically, 10-pound bags of potatoes. The research firm employed several different banding methods in unitizing four, five and six bag units, which included high strength plastic bands, fiber bands, heat shrinkable plastic bands and continuous multi-bag units. A continuous bag unitizing method showed more promise for reducing costs than the other methods studied. Potential savings from the continuous bag method over the present method of unitizing the consumer-size bags by putting them in multi-wall master bags and fiber-board cartons were 50 cents to \$1.00 per hundred pounds.

RPA 906 - CULTURE AND PROTECTION OF ORNAMENTALS AND TURF

Flower Transport

Work was continued on the evaluation of possible economies and advantages of cutting, handling, and air shipment of carnations in the bud instead of open flower stage. Time studies were made at greenhouses in Denver, Colorado, area to determine the average cost for cutting, movement to grading room, grading, and bunching of flowers cut in the open stage compared to flowers cut in the bud stage. It was found that all of these operations could be performed faster with buds than with open flowers. Also, more buds than open flowers could be put in a carrying saddle, thus reducing the number of trips and cost for movement from the bench to the grading room.

Buds are more compact and take up less space than a like quantity of open flowers. Experiments show that about three times as many buds as open flowers can be packed in a carton. Therefore, a bud distribution system would require only about one-third as many cartons as the present system. Also, it was found that the packed weight of bud carnations is about 33 percent less than for an equal number of open flowers, so density was only doubled.

Based upon experiments thus far, it is estimated that savings in transport and handling costs of carnations shipped by air out of Colorado and California, if flowers were shipped in the bud instead of open stage, would be over \$1 million a year. In F.Y. 1969, it is intended to make some commercial shipments to explore further the feasibility of a bud distribution system.

RPA 509 - MARKETING FIRM AND SYSTEM EFFICIENCY

A. Loading Techniques and Load-Securing Devices for Rail-Piggyback Highway Trailers

The cost of transporting agricultural perishables includes losses from damage during transit which amount to millions of dollars each year. Some of these losses result from the use of poor loading and load securing techniques. The objective of this research is to develop improved loading techniques and load-securing devices that will reduce load shifting and damage to the products and shipping containers in highway and rail piggyback shipments. During the year observations were made of load securing devices and techniques on all test and control shipments originated in the conduct of other research. Researchers gathered data on the types of devices and techniques used to secure the loads in the transport vehicles, the performance of the device, and the amounts of cargo damage and losses incurred when loads shifted. Two prototype, lab constructed, load securing devices were tested.

B. Handbook for Refrigerated Truck Operators

Data were gathered for a handbook which will set forth recommended methods for loading, protecting, and refrigerating perishables in truck-trailers to

reduce product loss and damage during transit. Information was obtained through review of available literature, interviews with government and industry officials, and observation of loading and unloading of trailer loads of perishables in major growing and receiving areas. These areas included the Pacific Northwest, California, Florida, and the Eastern seaboard.

At the end of the reporting period, the manuscript for the handbook, covering recommended techniques for loading and meeting the protective requirements for each of 48 perishable products was 80 percent complete. Writing, review, editing and publishing of the handbook will be completed during the coming year.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U. S. PRODUCTS

A. Improved Transport Techniques for Overseas Shipments.

1. Fresh Fruits and Vegetables. Four test container van loads, two each of fresh radishes and celery, were made from Florida to Europe. The two loads of radishes were shipped in waxed fiberboard boxes. One of the radish shipments was loaded using the conventional, wood-stripped stacking pattern, and the other using a new air-flow pattern developed during the year. The new pattern provided adequate air circulation around each box and eliminated the use of wooden strips between the layers of boxes, saving the shipper approximately \$25.00 per load compared to the conventional loading method. While, as in previous years, no radishes were shipped to Europe in 1967, there were 126 40-foot long refrigerated van container loads shipped from the U. S. in 1968. The 1968 volume is partly attributable to this research which helped to get the radishes to overseas markets in better condition.

The two van container loads of celery were sent to the U. S. Army at Kaiserslautern, Germany. Both loads were handled in the conventional manner with one ton of top ice placed on the top layer of cargo in the vans. A garden soaker hose was installed in one load. After the top ice melted, water was added for five minutes each day to determine if any benefits could be gained by adding moisture to shipments of leafy vegetables during transport. Because of the limited number of tests made, most of the results were inconclusive. Additional data were gathered on transport time, damage, refrigeration, insurance, documentation and handling costs and labor, and capital inputs. A research report on the shippers' cost for overseas shipments of fresh fruits and vegetables was written during the year.

2. Dried Beans. At the request of the Michigan Bean Commission, the unloading of 6,000 tons of dried Michigan Navy Beans from three different ships at Liverpool, England was observed. The beans were shipped in 100-pound burlap bags. Data were obtained on the type and extent of damage which occurred during unloading and related transport and handling. In the unloading of all three ships many beans were lost through spillage when the bags were ruptured or torn during handling from the ship's hold to the pier. Also, in one 400,000-pound shipment, 5,000 pounds were lost when they were damaged by

water in the hold of the ship. The data gathered in this work will be used to plan further research to find ways to reduce costs and losses in shipping dried beans to overseas markets.

3. Frozen Poultry. Four containerized and three break-bulk test shipments of frozen poultry were made in the fall of 1967 to ports in Europe. A containerized and a break-bulk shipment were made to Japan in the spring of 1968. The containerized shipments arrived at destination in excellent condition with no loss from pilferage or damage. The product in the van containers was less exposed to unfavorable temperatures during transit.

The fewer handlings of individual packages in the van container shipments led to reduced handling costs and product losses from handling damage and pilferage. Furthermore, the quicker transfer of cargo from one transport mode to another reduced overall transit time.

Labor costs averaged 7 times as much for the break-bulk shipments as for the van container shipments, 7 cents per pound as compared to 1 cent per pound. Labor productivity was 19,837 pounds per man-hour for loading and unloading van container shipments on and off the ships and 1,207 pounds per man-hour for loading and 318 pounds per man-hour for unloading break-bulk shipments.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Transport Equipment

Goddard, W. F., Jr., August 1967. Blueprint for Reefer Units, Container News.

Phillips, C. W., NBS, and Penney, R. W., TFRD, ARS. September 1967. Development of a Method for Testing and Rating Refrigerated Truck Bodies. USDA Technical Bulletin No. 1376.

Penney, R. W., TFRD, ARS, and Phillips, C. W., NBS. November 1967. Refrigeration Equipment for Truck Bodies--Effects of Door Usage. USDA Technical Bulletin 1375.

Clayton, J. E., December 1967. Multi-purpose Van Development. Refrigerated Transporter.

Goddard, W. F., Jr., January 1968. Air Conditioned Transport (Carriage) for Agricultural Commodities. Modern Refrigeration and Air Conditioning Magazine Croydon Survey, Great Britain.

Transport Techniques

- Nicholas, C. J., July 1967. Opportunities for Cutting Costs of Shipping Poultry Overseas. Broiler Industry.
- Clayton, J. E., September 1967. Research to Develop Optimum Transportation Techniques for Perishable Products. Transporti Industriali - Italy.
- Clayton, J. E., October 1967. Containerization in Transporting Agricultural Perishables. A paper presented at the Conference on Containerization of the First International Container Show, Genoa, Italy.
- Clayton, J. E., October 1967. Containerization--A New Approach to Transportation of Agricultural Products. ARS Radio Service 'Agri Tape', Coverage 550 stations.
- Clayton, J. E., October 1967. New Developments in Transporting Products. Proceedings of the Sixteenth Annual Meeting of the Agricultural Research Institute, National Academy of Sciences, National Academy of Engineering, Washington, D. C.
- Clayton, J. E., 1968 Yearbook. Piggyback-Containerization and Fresh Fruits and Vegetables. United Fresh Fruit and Vegetable Association.
- Clayton, J. E., Winter 1967. Approaches, Opportunities, and Transport Job Ahead. Transportation Journal.
- Clayton, J. E., February 1968. Pace Quickens for Intermodal Perishable Moves. Container News.
- Chapogas, P. G., March 1968. Expanding Exports Through Better Physical Distribution. A paper presented at the International Conference on Handling Perishable Agricultural Commodities, Purdue University, Lafayette, Indiana.
- Clayton, J. E., March 1968. Better Food Transport Through Bigger Handling Units. A paper for the First Inter-American Port Seminar, Bogata, Columbia.
- Anderson, D. L., April 1968. The Future of Meat Distribution. A paper presented at the Meat Packers and Processors Conference, Philadelphia, Pa.
- Hinds, R. H., Jr., April 1968. Research Accomplishments and Needs to Improve the Overseas Transportation of Fruits, Vegetables, and Other Agricultural Products. Testimony given at a hearing of the Senate Committee on Small Business, Miami, Fla.

Anderson, D. L., April 1968. Changes Needed in Refrigeration and Improved Distribution and Transportation of Meat Products. A paper presented at the Meat Operations Seminar, Kansas State University, Manhattan, Kansas.

Hinds, R. H., Jr., May 1968. Produce Transportation Problems and Equipment. A paper presented to the Super Market Institute Convention, Cleveland, Ohio.

Clayton, J. E., June 1968. Increasing Efficiency in Transport. A paper presented to the Capitol City Traffic Club of Virginia, Richmond, Va.

Crow, W. C., June 1968. America's Most Fundamental Success. Handling and Shipping.

Clayton, J. E., June 1968. Perishables for People: What Physical Distribution Must Do. Handling and Shipping.

AREA 9

WHOLESALE, RETAILING AND INSTITUTIONAL FOOD SERVICE

(RPA 509 - MARKETING FIRM AND SYSTEM EFFICIENCY)

USDA and Cooperative Program

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Maryland (Hyattsville)	Fresh Meat	1.0
Maryland (Hyattsville)	Fruits and vegetables	.5
Maryland (Hyattsville)	Bakery	.5
Maryland (Hyattsville)	All food products	2.2
Total		4.2

Intramural program is supplemented by extra mural support representing (a) .7 SMY's at State Agricultural Experiment Stations, (b) .3 SMY's at other U. S. institutions, (c) no P.L. 480 funds and (d) .7 SMY's with private consulting firms.

Problems and Objectives

The American system of producing and distributing food is supplying consumers \$86 billion worth of food annually. In 1967, it cost \$28 billion for growing the food and \$58 billion for marketing it. In the past 20 years marketing costs increased \$35 billion compared to an increase in production costs of \$9 billion. About half of the marketing cost was required for performing the wholesaling and retailing function. Reductions in operating costs for food wholesalers and retailers of 25 percent have been demonstrated and the potential savings of this research amounts to billions of dollars annually.

Major objectives of the research are to hold down or reduce rising food distribution costs and provide better food services to consumers by:

- (1) Increasing the operating efficiency of marketing firms through better operating methods, materials, equipment, layouts and business practices.
- (2) Assistance and advice to smaller firms to permit them to compete and thus maintain competition.
- (3) Development of food handling practices that bring food to consumers that is cleaner, more healthful and in better condition.
- (4) Strengthening the position of farm based marketing firms and thus farm interests by development of more efficiency in the distribution system.

Progress - USDA and Cooperative Programs

(All in-house work in this area was terminated January 1, 1968, due to budget limitations. Research under contracts or agreements where Federal monies were obligated is being carried to completion.)

A. Fresh Meat

1. Improved techniques of sanitation and temperature control for retailing beef. In cooperation with Missouri University research has been undertaken to improve retail store handling, sanitation and refrigeration practices. The contractor's reports were completed for this project and publication of the material will be done by the University of Missouri. The preliminary bulletin reporting this research, Missouri Manual 64, Guidelines for Handling Prepackaged Meat in Retail Stores, has had 65,000 copies distributed. Temperature control was found to be the most significant method of extending shelf life with the ideal temperature 30°F. on the meat surface plus or minus one degree. Good sanitation practices were desirable, but when highly refined and complicated cleaning techniques were used shelf life was actually reduced. Storage of packaged meats in darkness at 30°F.

resulted in practically no loss of color or saleable quality for 10 days. Packages removed from dark storage and displayed under light deteriorated at about the same rate as freshly packaged meat. This suggests that fresh beef could be packaged as much as two weeks prior to sale with proper handling and refrigeration.

2. Improved display and customer service for meat and poultry products in retail stores. Purchase order contract negotiations were entered into with Kansas State University to complete the field work on display case layout and arrangement and data collection was begun by KSU at Falleys, Topeka and in stores of the Fleming Company. When this work was terminated January 1, 1968, contract negotiations ceased and work completed on this phase of the project was filed. A purchase order contract to evaluate different wrapping films for meat was completed and a report prepared. The most significant factor in the maintaining of a saleable appearance of packaged meat was a low display case temperature, preferably at 30°F. surface temperature on the package. Meat displayed at 30°F. had more desirable color retention, less weight loss and lower bacterial growth than at 38°F. Also, at the 30°F. display temperature slightly more of the weight loss was absorbed by the packaging materials. Similar results occurred for meat packages held in darkness indicating that prepackaged meat not on display should be stored in an unlighted area. Indications are that the proper handling and displaying of meat is as important as the packaging film being used.

3. Improved handling systems for distributing beef and beef products from the farm to the consumer. A contract was developed with the A. T. Kearney Company of Chicago, Illinois, to determine the feasibility of a systems model to evaluate potential changes in the distribution of beef. A first draft of the contractor's report has been received. The contractor has interviewed approximately 85 organizations or authorities in the meat industry. The report recommends a descriptive mathematical model of the livestock and beef industry for use: to provide guidance to the industry on alternative operating methods; by individual companies to assess their position in the industry; as an educational device for universities and research organizations to help understand the distribution system; to direct research toward areas having the greatest potential for improvement; and to test the impact of proposed changes in operational methods, equipment, transport, organization, structure, location, pricing, regulation, reporting processes, etc. Sub-optimizing programs would be developed for 10 producing regions of the country and 13 segments of the industry. The report recommends a joint effort by government and various industry groups to develop the model, assemble the data, operate the model and up-date input information.

In addition, direction was provided to a Division-wide systems committee established to coordinate a research effort in the livestock and meat industry. The committee determined, after an extensive review of the industry, that the most pressing research need in the beef industry was to accumulate factual data on the handling methods, physical distribution costs, product

environment and special problems for beef moving from slaughter to the consumer. A contract proposal was prepared to gather chronological data on test shipments and to evaluate the effect of applying the best current technology at all levels to reducing costs and preserving the quality of beef.

B. Fruits and Vegetables

Research on warehousing frozen fruits and vegetables was completed and a marketing research report prepared. The report contains recommendations that increased labor productivity an average of 22 percent in nine frozen food warehouses through improved work methods, materials-handling equipment and layout. Another report, "Packaging Produce at the Central Warehouse--Trayed Items", was sent for publication and should be released in the fall of 1968.

C. Bakery

An evaluation of on-premise and bake-off bakery departments in retail stores was completed during the fiscal year. A marketing research report has been prepared which compares the bake-off and on-premise retail bakery systems at selected weekly sales volume levels and recommends methods for improving all retail bakery departments. The report has been edited and is currently being processed for publication. In addition, two supplementary reports on in-store retail bakery departments are being published by the University of Maryland covering work done in cooperation with the University.

D. All Food Products

1. Improved price marking and checkout for grocery stores. Research was conducted by the University of Delaware under purchase order contract on warehouse price marking of grocery products. A price marking line was developed, including a case cutter and pricing machine. Time studies were taken on the operation and standard times developed for the operation. A contractor's report was received and is being organized for a publication entitled, "Mechanical Price Marking of Grocery Products". An improved optical scanner was developed by a cooperator that can be attached to a printer. A final operating test of the improved scanner and printer will provide standard times for the automatic checkout, and an evaluation of the practicability of this method of checkout. Consultation meetings were held with National Cash Register Company and SWEDE and other firms interested in improved checkout and information gathering systems. The contract and agreement work will be completed and the two reports published on price marking and the feasibility of the automatic checkout.

2. Developing low cost retail food stores. Cooperative agreements were administered with Purdue University on factors contributing to low cost stores and with Ohio State University on development of operating standards for retail stores. These agreements involving committed Federal funds will be completed and published.

Most of the analysis on the Purdue agreement is complete and final report preparation is underway. Low cost independent food stores have been identified as having: (1) high sales per square foot of space; (2) low wage expense through high productivity often with relatively high wage rates per hour; (3) an owner-operator, working manager; (4) a low gross margin; (5) a lower level of advertising and promotion expense; (6) a young store; (7) large stores open long hours and small stores open short hours; and (8) high net operating profits. The least cost stores had the lowest gross margins and highest net operating profits indicating independent food retailing profits come from lower operating costs rather than higher gross margins. Wholesaler affiliation was especially significant for smaller retailers. Certain wholesalers apparently have the ability to create low cost affiliated retailers. For larger retailers wholesale affiliation was not so important a factor in operating costs, probably a reflection of the larger retailer's bargaining power. The most significant finding was that under the right conditions small independent stores can compete.

Data on 52 weeks of meat sales in four supermarkets and for 33 weeks in eight supermarkets have been analyzed and put into a forecasting model by Ohio State University. Price reductions or size of newspaper features could not be used to predict weekly meat sales. Activities of major competitors were significant in relation to sales; however, transferal of customer purchases tended to be from one feature item to another within the same store rather than from one store to a competing store. Sales predictions are being coupled with labor and other cost data to develop improved computer models for cost scheduling.

A purchase order contract was prepared to study the store layout practices of retail firms in order to determine why supermarkets are built which are inefficient to operate and too large or expensive for the location, thus adding "built in" costs to food retailing. Plans were prepared for two demonstration supermarkets incorporating all the research done by the Branch to test the hypothesis that low cost food retailing is possible. Research was begun on size and arrangement of food store parking lots and parcel pickup services in order to reduce the costs and improve the performance of these functions. A literature search and two store studies were completed. These three activities were dropped January 1, 1968.

A contract was prepared in cooperation with the U. S. Wholesale Grocers' Association and negotiations begun with a consulting firm to study 40 successful small independent food stores in ghetto areas of large cities and in Appalachian rural areas to identify the reasons for success and the operating practices that are needed to supply food at low costs to poor people. Plans were made to set up demonstration low cost food stores based on the proposed analysis and the Purdue low cost stores study. These stores were to be independently owned and operated and served by smaller wholesalers. Negotiations ceased and this work was terminated January 1, 1968.

The Federal-State Extension Service continued to cooperate with the Branch in getting research results adopted by all types of food distribution firms.

However, no training clinics or education exhibits involving Branch personnel were held.

3. Improved operational efficiency for complete line wholesale warehouses. In-house research on this project was stopped on January 1, 1968. Work is being completed on four purchase order contracts under this project: (1) a study of the optimum use of warehouse racking, (2) a determination of optimum warehouse ceiling height, (3) cost of servicing various size orders, and (4) use of computer model to predict warehouse produce movement. The project will be completed after the receipt and publication of these findings developed under the contracts.

4. Improved operational efficiency in institutional wholesale food distribution. Due to a heavy demand for Marketing Research Report No. 752, "Determining Costs of Servicing Institutional Grocery Orders", the initial printing was exhausted and a second printing was found necessary. The president of a national trade association stated that "this research has made a major contribution towards the development of scientific pricing policies by institutional distributors". Presentation of the findings of this research has been made to every major grocery trade association in the United States. The next step in the program was the development of computer time sharing concepts for institutional distributors. The Institutional Foods Manufacturing Association was considering a cash contribution of \$25,000 to the Department to jointly finance this research. The Institutional Food Distributors of America was instrumental in securing this cooperation. However, as of January 1, 1968, this work was discontinued.

5. Determining operational efficiency for commercial cafeterias. The average cafeteria which participated in this study could reduce labor costs \$35,600 annually through improved scheduling and supervision. Of the total direct labor time, approximately 17 percent was spent in walking. This represents the equivalent of nearly seven people walking continuously and points out the need for the development of "self contained" work stations designed for a worker using good work methods. Observations of unique operating practices and management procedures, which were incorporated in the study, indicate that substantial savings are available through the application of methods improvements. For example, those cafeterias which had a normal training program achieved multiple job assignments which resulted on the average, in a three percent less payroll ratio or annual savings of \$49,700 each. The final report should be available to the general public within the next six months.

6. Improved operational efficiency for food service outlets. Man-hour requirements per 100 customers and the percent labor utilization was determined by work sampling at 12 locations for 13 commercial table service restaurants. Studies were conducted and data summarized from the following location studies: Washington, D. C.; Seattle, Washington; San Francisco, California; Scottsdale, Arizona; Salt Lake City, Utah; Chicago, Illinois;

Kansas City, Missouri; Houston, Texas; New Orleans, Louisiana; St. Petersburg, Florida; Atlanta, Georgia; and Boston, Massachusetts. The man-hour requirements, labor utilization, work methods and layouts for two types of commercial, table service restaurants were developed. It was found that labor costs averaged 31 percent of sales--an amount almost equal to the cost of food purchased. The study showed that labor was used effectively in the restaurants studied only 74 percent of the time. The research developed methods and proceedings to effectively use 95 percent of labor hours. Application of these findings to the 4,000 restaurants in this size group would bring a total annual savings of \$1,200 million. The study also indicated that additional savings can be made by developing improved layouts, equipment, and work methods. The research was conducted through a cooperative agreement with the National Restaurant Association and the University of Delaware. A report will be released documenting the research.

7. Appraisal of problems and research needs of the food service industry. Five hundred and fifty-nine reports and publications have been received, reviewed, and abstracted by the contractor. There were eight hundred contacts made with the following segments of the food service industry:

<u>No. Contacts</u>	<u>Organization Description</u>
40	Food service associations
60	Educational associations and colleges
240	Institutional food manufacturers
100	Institutional food equipment manufacturers
100	Members - Council on hotel, restaurant and institutional education
250	Multi-unit operators
10	Food service magazines

The contractor is finalizing a report which will present abstracts of available research publications and research deficiencies in the following areas: management, operations, customer service, economy of scale, and central food preparation.

Publications - USDA and Cooperative Programs

Fresh Meat

Anderson, D. L. 1968. Directions of Change in Meat Distribution. Meat Science and Distribution Conference, Ohio State University.

Anderson, D. L.; Doordan, M. L.; Naumann, Donald; Stringer, William. 1968. Evaluation of Selected Wrapping Films for Fresh Meat Packaging, ARS 52-33.

Anderson, D. L. 1967. Considerations in Packaging Fresh Meat In Central Locations. National Packaging Forum, Chicago, Illinois.

Hedrick, H. B.; Marriott, N. G.; Naumann, H. D.; Stringer, W. C. 1967. Color Stability of Prepackaged Fresh Beef as Influenced by Pre-display Environments. Food Technology, Volume 21, No. 11, pp. 104-106.

Fruits and Vegetables

Bouma, John C. 1968. Operations--Warehousing and Delivery. Speech delivered before the IFDA annual convention, Washington, D. C.

Lundquist, Arnold L. 1968. Improved Handling Methods and Layout in Affiliated Frozen Food Warehouses. MRR 823.

Lundquist, Arnold L. 1968. Distributors Could Cut Warehouse Labor Costs 22%. Frozen Food Age. (July 1968 issue)

Lundquist, Arnold L. 1968. How to Improve Refrigerated Warehousing Operation, to Increase Labor Output. Quick Frozen Foods (August 1968 issue).

Karitas, James J. 1968. Packaging Produce at the Central Warehouse--Trayed Items. Marketing Research Report No._____.

Bakery

Doordan, Martin L. and Volz, Marvin D. 1968. An Evaluation of On-premise and Bake-off Bakery Departments in Retail Food Stores. Marketing Research Report No._____.

Doordan, Martin L. and McDonald, Russell F. 1968. Retail Store On-Premise Bakery Departments: Two Case Studies. MP 665. University of Maryland Agricultural Experiment Station, College Park, Maryland.

McDonald, Russell F. and Doordan, Martin L. Retail Store Bake-off Bakery Departments: Two Case Studies. MP. 668. University of Maryland Agricultural Experiment Station, College Park, Maryland.

All Food Products

Anderson, Dale L. 1967. Operating Perishable Foods Departments, Japan Self-Service Association, Tokyo, Japan and Osaka, Japan.

Anderson, Dale L. 1967. How to Develop An Affiliated Food Wholesaler-Retailer Relationship. Nitti Conference for food distribution firms, Tokyo, Japan.

- Bouma, J. C. 1967. Improved Operational Performance in Institutional Food Distribution Warehouses. National American Wholesale Grocers' Association, Chicago, Illinois.
- Bouma, J. C. 1968. The Automatic Checkout. National American Wholesale Grocers Association.
- Freshwater, J. F. 1967. A Productivity Index for Cafeteria Workers. Cornell Hotel and Restaurant Administration Quarterly.
- Freshwater, J. F. 1968. Labor Utilization and Operating Practices in Commercial Cafeterias. Marketing Research Report No. 824.
- Freshwater, J. F. 1968. Employee Productivity in Table Service Restaurants. Marketing Research Report No. _____.
- Hoecker, Dr. R. W. 1967. The Store of the Future. 12th Annual Convention. Quebec Food Retailers Association, Inc., Montreal, Canada.
- Hoecker, Dr. R. W. 1968. The Future of Merchandising. Consumers' Cooperative Managers Association, San Juan, Puerto Rico.
- Hoecker, Dr. R. W. 1968. The Past, Present, and Future for Food Distribution Research. Supermarket Management Workshop, Farmingdale, New York.
- Karitas, J. J. 1967. Determining Costs of Servicing Wholesale Institutional Grocery Orders. National Convention of the Frozen Food and Frozen Food Packers' Association. New York.
- Karitas, J. J. 1967. Servicing Costs for Institutional Wholesale Grocers. Frozen Food Association of Washington-Baltimore, College Park, Maryland.
- Marion, Bruce W. and Bay, Lloyd. 1968. A Conceptualized Management Information System for Marketing Firms. American Agricultural Economic Association.

MISCELLANEOUS

Plan and Establish Essential Marketing Facilities in Brazil. It is estimated that in Brazil, 35 percent of such perishable foods as fruits and vegetables and 25 percent of such semi-perishable products as grain are lost from waste and spoilage caused by poor handling. Work has been done on the development of central wholesale markets at Recife, Salvador, and Fortaleza; on facilities for the largest poultry and egg marketing cooperative in north-eastern Brazil; and on the development of better retail outlets for food. Indicative of the results are: the percentage of produce moving into Recife handled by the market has increased from 15 percent to 75 percent; the number of birds processed in a poultry and egg cooperative increased during an eight-hour day from 2,500 to 4,600, using the same equipment with a better job being done on quality control; the volume of eggs handled per month in the same cooperative increased from 30,000 dozen to 100,000 dozen with improved packaging and more sanitary conditions; and plans for two shopping centers in the Recife area have been developed as pilot projects.

Minimizing Damage to Food Processing Plants in Case of Nuclear Attack. The preliminary draft of a report entitled, "Facility Protection Handbook on Minimizing Damage to Food Processing Plants in Case of Nuclear Attack," has been received from the URS Systems Corporation. The contract under which this work is being done is financed by the Office of Civil Defense under an agreement between ARS and that agency. The report discusses nuclear weapon effects, food processing requirements, vulnerability and potential damage, reducing vulnerability of food facilities and restoration of production. Following the general treatment of these subjects, the report discusses the application of these points to eight types of food processing plants: flour mills, bakeries, meat packing plants, oil seed mills, shortening manufacturing plants, dairy manufacturing plants, food canning plants, and sugar refineries. The final report will be illustrated.

